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Simulation of Nutrient Loadings in Surface Runoff with the NPS Model

Hydrocomp, Inc, Palo Alto, Calif

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The Nonpoint Source Pollutant Loading (NPS) Model was applied to one urban and two small agricultural watersheds to simulate nutrient loadings in surface runoff. Since the NPS Model simulates all nonpoint pollutants as a function of sediment loss, the key question was whether sediment is a reliable indicator of nutrients in surface runoff. Both the literature surveyed and the results of this work indicate Total nitrogen (N) and Total phosphorus (P) can be reasonably simulated in this manner. Also, organic components of N and P can be simulated since they are generally associated with sediment and comprise a major portion of the total nutrients in surface runoff.

Nitrate N (NO_3-N) and phosphate P (PO_4-P) are almost entirely contained in the soluble fraction of surface runoff and are not adequately simulated with the NPS Model. Ammonia N (NH_3-N) appears to be transported in significant amounts both in solution and attached to sediment; thus, the simulation results were inconclusive. Total Kjeldahl N (TKN) was simulated on the urban watershed which was large enough to provide a continuous baseflow. The simulated TKN values agreed reasonably well with recorded values except when baseflow TKN concentrations were high. Over 50% of the annual TKN loading was estimated to originate from the baseflow. Therefore, the NPS Model can simulate total nutrient loadings only in areas where subsurface contributions are minimal.

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SIMULATION OF NUTRIENT LOADINGS IN SURFACE RUNOFF WITH THE NPS MODEL

by

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FOREWORD

As environmental controls become more costly to implement and the penalties of judgment errors become more severe, environmental quality management requires more efficient analytical tools based on greater knowledge of the environmental phenomena to be managed. As part of this Laboratory's research on the occurrence, movement, transformation, impact, and control of environmental contaminants, the Technology Development and Applications Branch develops management or engineering tools to help pollution control officials achieve water quality goals through watershed management.

Techniques for estimating the contribution of various land use activities to nonpoint source pollution are essential to the development of water quality management plans for specific areas. The Nonpoint Source Model, which was developed to simulate pollutant contributions to stream channels for nonpoint sources, was expanded to include nutrients. This report documents the expanded effort and illustrates the additional testing given the model.

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ABSTRACT

The Nonpoint Source Pollutant Loading (NPS) Model was applied to one urban and two small agricultural watersheds to simulate nutrient loadings in surface runoff. Since the NPS Model simulates all nonpoint pollutants as a function of sediment loss, the key question was whether sediment is a reliable indicator of nutrients in surface runoff. Both the literature surveyed and the results of this work indicate total nitrogen (N) and total phosphorus (P) can be reasonably simulated in this manner. Also, organic components of N and P can be simulated since they are generally associated with sediment and comprise a major portion of the total nutrients in surface runoff.

Nitrate N (NO_3-N) and phosphate P (PO_4-P) are almost entirely contained in the soluble fraction of surface runoff and are not adequately simulated with the NPS Model. Ammonia N (NH_3-N) appears to be transported in significant amounts both in solution and attached to sediment; thus, the simulation results were inconclusive. Total Kjeldahl N (TKN) was simulated on the urban watershed which was large enough to provide a continuous baseflow. The simulated TKN values agreed reasonably well with recorded values except when baseflow TKN concentrations were high. Over 50% of the annual TKN loading was estimated to originate from the baseflow. Therefore, the NPS Model can simulate total nutrient loadings only in areas where subsurface contributions are minimal. This report was submitted in fulfillment of Grant No. R803315-01-2 by Hydrocomp Inc. under the sponsorship of the Environmental Protection Agency. The work was completed as of October 1976.

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LIST OF SYMBOLS AND ABBREVIATIONS

SYMBOLS

Fe	= iron
N	= nitrogen
NH_3	= ammonia
NH_3-N	= nitrogen in the ammonia form
NO_3	= nitrate
NO_3-N	= nitrogen in the nitrate form
P	= phosphorus
PO_4	= phosphate or orthophosphorus
PO_4-P	= phosphorus in the phosphate form
TKN	= total Kjeldahl nitrogen, i.e. organic nitrogen and ammonia nitrogen

ABBREVIATIONS

cm	= centimeters
cms	= cubic meters per second
gm/ha	= grams per hectare
ha	= hectare
kg/ha	= kilograms per hectare
m	= meters
mg/l	= milligrams per liter
mm	= millimeters

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At Hydrocomp, Dr. Norman H. Crawford was the principal investigator and Mr. Anthony S. Donigian, Jr. was the project manager. Mr. Harley H. Davis assisted in the literature search and analysis, nutrient data analysis, and model application. Drafting duties were ably performed by Mr. Guy Funabiki and the report was edited and typed by Ms. Donna D'Onofrio.

SECTION 1.0

CONCLUSIONS AND RECOMMENDATIONS

The Nonpoint Source Pollutant Loading (NPS) Model can be used to estimate total nutrient loadings from the land surface of urban and agricultural areas. Test results on a 433-hectare (ha) urban watershed (Third Fork Creek) in Durham N.C. show that simulated total phosphorus (P) and iron (Fe) concentrations during a storm compare well with recorded values. Total annual loadings for 1972 were within 20% of the values estimated from regression analysis of the data. Simulated total Kjeldahl nitrogen (TKN) concentrations and loadings were less accurate due to TKN concentrations in baseflow. Since in-stream processes and subsurface pollutant contributions occur in Third Fork Creek and are not simulated in the NPS Model, the size of the watershed approaches the upper limit of applicability of the model.

Where subsurface contributions are significant, the NPS Model should be modified to allow specification of average monthly pollutant concentrations in subsurface flow. If in-stream processes are major, the NPS Model should be interfaced with a stream water quality model. Both of these procedures would be required to simulate nonpoint pollution in large watersheds.

Nutrient concentrations and loadings were also simulated from two small agricultural watersheds (1.3 and 0.8 ha) in Watkinsville, Georgia and East Lansing, Michigan for the 1974 growing season. Total P and total nitrogen (N) concentrations and loadings were adequately simulated because these nutrient forms are largely associated with the sediment fraction of surface runoff. Ammonia nitrogen (NH_3-N) values were not simulated as well as total P and total N since NH_3-N transport in solution was found to be significant. Nitrate nitrogen (NO_3-N) and phosphate phosphorus (PO_4-P) values were not adequately represented because they are transported almost entirely in solution form. Accordingly, the NPS Model should not be used to estimate loadings for these nutrient forms.

Just as Third Fork Creek approaches the upper size limit for the NPS Model, the agricultural watersheds were too small for accurate representation of the hydrologic and sediment characteristics. The NPS Model should only be applied to watersheds for which the 15-minute simulation interval is reasonable. The range of watershed sizes simulated in this study (0.8 to 433 hectares) provides estimates of the upper and lower bounds of applicability.

The nutrient simulation results were obtained by estimating the nutrient potency factors (i.e. nutrient loss/sediment loss x 100%) from observed

data and then calibrating the values by comparing simulated and recorded concentrations. The goal was to evaluate the use of sediment loss, as simulated in the NPS Model, as an indicator of nutrient loadings in surface runoff. Further testing and verification should be conducted to see if the potency factors can be estimated, without calibration, as a function of fertilizer applications, management practices, soil characteristics, crop behavior, etc. Only in this way can the NPS Model be effectively applied in areas where little data is available.

The conclusions presented in this report do not mean that soluble nutrient forms are unimportant. In areas where subsurface flow is a major portion of total runoff, soluble nutrient forms may comprise much of the nutrient loading. The literature and results of this work indicate that total nutrient loads in surface runoff are associated largely with sediment. Until research can accurately represent the complex reactions and transformations of nutrient forms in all flow components, the NPS Model can be used to estimate total nutrient loads in surface runoff as a function of sediment loss.

SECTION 2.0

INTRODUCTION

This report presents the results of further testing of the NPS Model to specifically evaluate its applicability for simulating nutrient loadings from urban and agricultural watersheds. The NPS Model has been described in a previous EPA report (1). The reader is referred to the original report on the development and testing of the model which also provides guidelines for its use and application.

The NPS Model was developed to provide a tool to regional, state, and local planning agencies for the evaluation and analysis of nonpoint pollution problems. The model continuously simulates hydrologic processes, including snow accumulation and melt, pollutant accumulation, generation, and washoff from the land surface. Sediment and sediment-like material is used as the basic indicator of nonpoint pollutants. These erosion processes are simulated on both pervious and impervious areas. Pollutant loadings are determined by multiplying the resulting sediment discharge by "potency factors" i.e. pollutant mass/sediment mass x 100 percent, representing the pollutant strength of the sediment. The potency factors are specified for each pollutant by the user as single average values or 12 monthly values; the same potency factors are used throughout the simulation period.

The NPS Model is called a "pollutant loading" model because it simulates the total input or pollutant loading from the land surface to a stream channel or waterbody. Although the hydrologic algorithms simulate all runoff components (surface runoff, interflow, groundwater flow), the present version of the model evaluates only surface pollutant contributions. Subsurface, groundwater pollutants, and channel processes are not considered. For water quality simulation in watersheds where in-stream processes are significant, the NPS Model must be interfaced with a stream water quality model.

Since the NPS Model simulates all pollutants as a function of sediment washoff, the goal of this work was to evaluate how well this assumption works for various compounds of nitrogen (N) and phosphorus (P). A review of the literature has shown the majority of the Total N and Total P in surface runoff from agricultural lands is associated with the sediment fraction. Burwell, et al (2) estimate more than 96% of Total N and 95% of Total P losses in surface runoff from experimental plots (4.05 meters (m) x 22.13 m) in Minnesota were transported by sediment. These values pertain to plots managed as continuous fallow, continuous corn, and rotation corn. Plots managed as rotation hay produced little sediment loss with all of the

runoff nutrients occurring in soluble form. However, the absolute value of soluble nutrient losses were low for all the experimental plots. Organic N on sediment was the predominant nitrogen form, except during snowmelt periods when nitrate nitrogen (NO_3-N) was prevalent. Ammonia nitrogen (NH_3-N) losses occurred both on sediment and in solution in almost equal proportions. Phosphorus losses were measured largely as total P on sediment except for some Ortho-P (PO_4-P) and total P in solution during snowmelt. In general, soluble nutrient losses occurred during the snowmelt period which produces most of the annual runoff.

Kissel, et al (3) noted similar results for nitrogen losses from duplicate 4-hectare (ha) watersheds in Texas. Runoff samples collected over a 4-year period indicate 86% and 77% of total N was transported by sediment from the two watersheds planted on a rotation of grain sorghum, cotton, and oats. Johnson, et al (4) found that 80% of the total P losses from a 330 km rural watershed in central New York were attached to the suspended solids measured in the stream. Most of the solid phase P was insoluble phosphate compounds and organic P. Using simulated rainfall on plots in Indiana, Romkens, et al (5) found high percentages of total nutrients in surface runoff were components of sediment under five different tillage systems. However, tillage practices that reduced sediment loss would also reduce sediment associated nutrient losses, but would increase the soluble nutrients in the surface runoff. An almost linear relationship (referred as "curvilinear") was established between sediment loss and sediment-associated N and P losses. On four watersheds (30 to 60.8 ha) in Southwestern Iowa, Schuman, et al (6) observed the percent of total N losses associated with sediment was 92% for contour-planted corn watersheds and 51% for pasture watersheds. However, total N losses from the pasture watershed was only 7.6% of the contour-planted watershed. Annual soluble N losses were low from all four watersheds during the 3-year study.

Urban watersheds have not been as extensively monitored for the transport mechanisms of nutrient losses as have agricultural areas. In a study on nutrient loadings to a lake from urban residential land, Kluesener (7) and Kluesener and Lee (8) noted a striking similarity between the measured total solids concentrations and the Organic N and total P concentrations during storm events. Sediment appeared to be the major transport mode for these constituents. Organic N was responsible for 77% of the total N loading. Data presented by Cowen et al (9) for the same area showed Organic N was commonly associated with particulate matter. In a major study in Durham, N.C., Colston (10) extensively sampled solids, nutrients, organics, and metals from a mixed land-use urban watershed for an 18-month period. Colston's data showed a close correlation between Total Kjeldahl N (TKN), Total P, and the solids concentration. The more soluble nutrient forms (e.g. NO_3, PO_4, NH_3) were not analysed so no indication of their relative importance was possible.

In summary, the literature appears to indicate sediment can be used as a reasonable indicator of nutrient loadings by surface runoff from agricultural and urban lands. However, soluble nutrient losses can be significant in watersheds where subsurface discharge is a major component of the runoff. Burwell, et al (11) found subsurface transport of soluble N

accounted for 80% of the total N loss from level-terraced and pasture watersheds. But looking only at the surface runoff from those same watersheds, 75-80% of the surface N losses occurred on the sediment. The intent of this investigation was to evaluate the use of sediment as an indicator of nutrient loadings in surface runoff as formulated in the NPS Model. Section 3.0 describes the three test watersheds and Section 4.0 presents the simulation results. Estimating nutrient potency factors is discussed in Section 6.0 and general value ranges are included. The appendices provide a description of the minor modifications to the NPS Model performed during this study, correction of errors noted in the NPS Model report, and a new listing of the NPS Model.

SECTION 3.0

TEST WATERSHEDS

Simulation of nutrient loadings with the NPS Model was performed on one urban watershed and two small agricultural watersheds. The urban watershed is the Third Fork Creek in Durham, N.C. and the agricultural watersheds are the P2 watershed in Watkinsville, Georgia and the P6 watershed in East Lansing, Michigan. These watersheds were chosen because of data availability and previous simulation work. Third Fork Creek was one of the test areas for the NPS Model development work and the P2 and P6 watersheds are test sites for continuing research work on the simulation of pesticides and nutrients on agricultural lands (12).

Third Fork Creek represents a typical urbanized area in the Piedmont region of the Southeastern United States. The basin encompasses a variety of land uses in the general categories of residential (60%), commercial (17%), industrial (13%), and open land (10%). Upper Third Fork Creek, simulated in this study, drains an area of 433 ha located within the city limits of Durham, North Carolina (Figure 1). The watershed contains approximately 30% impervious land and has been the subject of urban runoff studies by Colston (10) and Bryan (13). The NPS Model report (1) provides a complete description of Third Fork Creek and the data used in simulation.

P2 and P6 are small experimental agricultural watersheds on which recent data collection and analysis programs have been sponsored by the U.S. Environmental Protection Agency. In cooperative agreements with the USDA Southern Piedmont Conservation Research Center (Watkinsville, Georgia) and Michigan State University's Department of Crop and Soil Science and Department of Entomology, the Environmental Research Laboratory in Athens, Georgia directed these programs. Instrumentation was established for continuous monitoring of meteorologic conditions and continuous sampling of runoff and sediment from the experimental watersheds. The collected samples and periodic soil cores were analyzed for both pesticide and nutrient content. Field operations, chemical applications, and crop growth were monitored on four watersheds in Georgia and two watersheds in Michigan. The general goal is to provide extensive data for the development of simulation models for evaluating nonpoint pollution from agricultural lands and the impact of land management practices. These programs and model development are described in a report by Donigian and Crawford (12).

P2 (Figure 2) and P6 (Figure 3) are small natural watersheds draining 1.3 and 0.8 ha respectively. Both watersheds were planted to corn in 1974 with

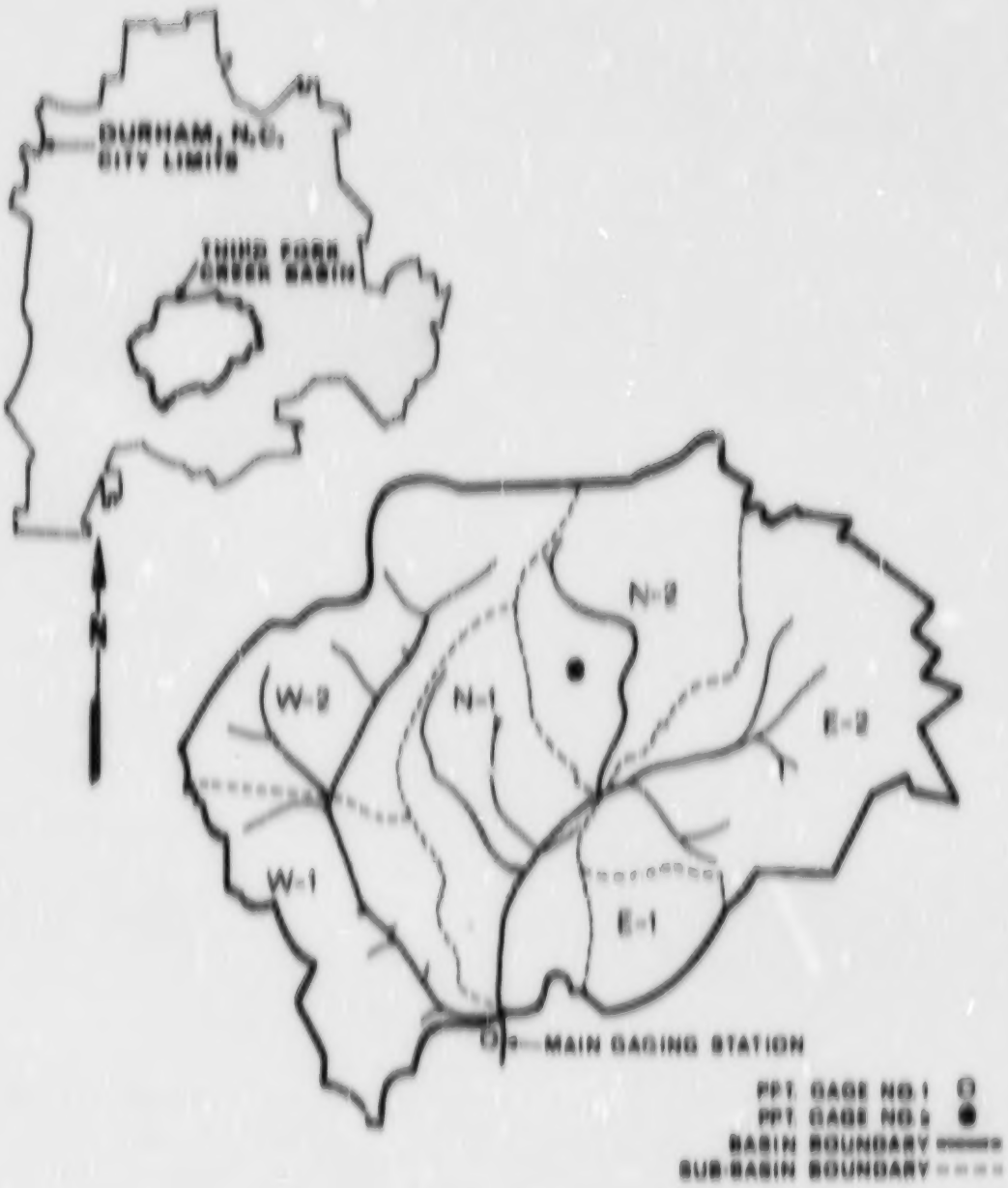

Figure 1 Third Fork Creek, Durham, North Carolina

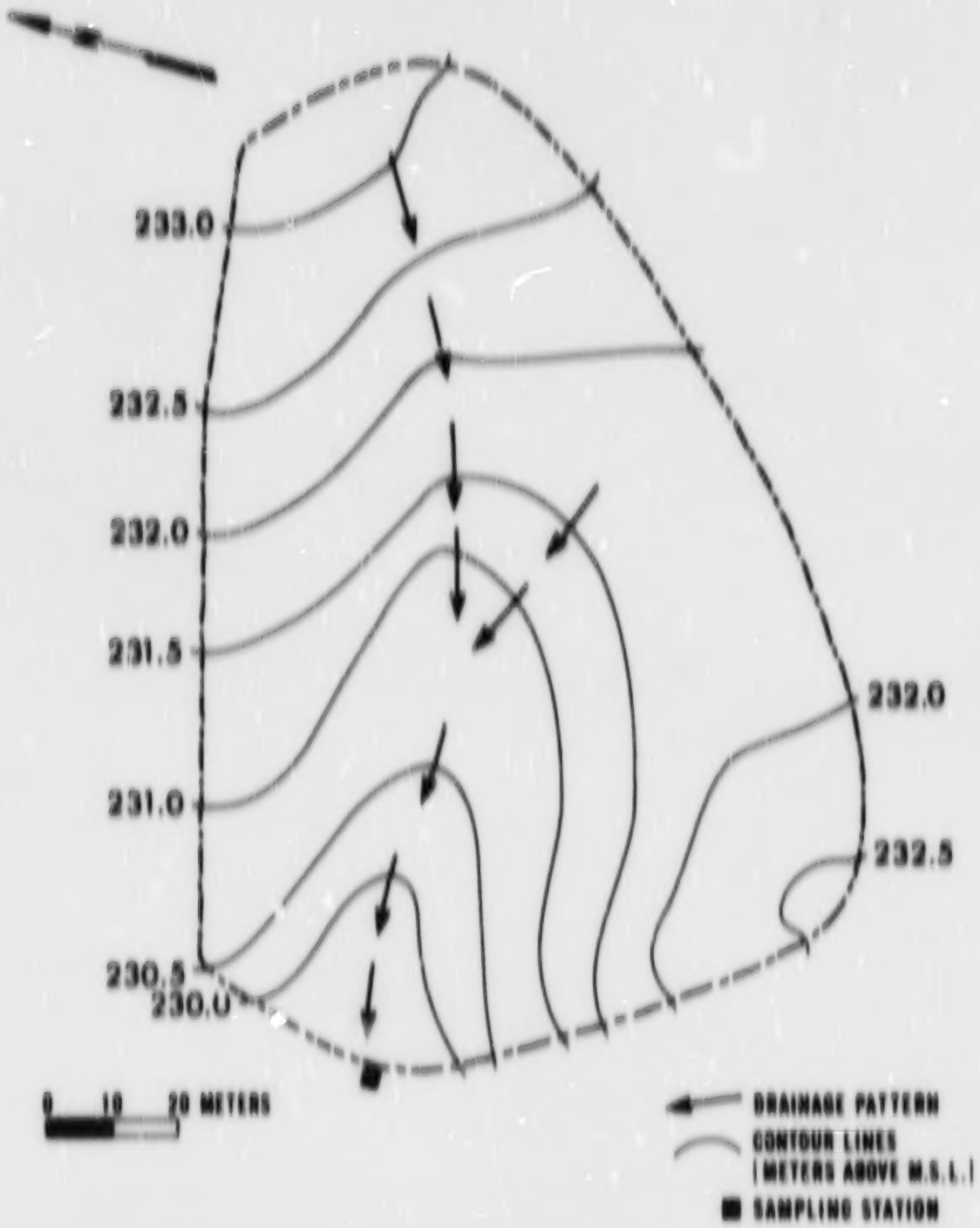

Figure 2. P2 Watershed, Watkinsville, Georgia (1.3 ha)

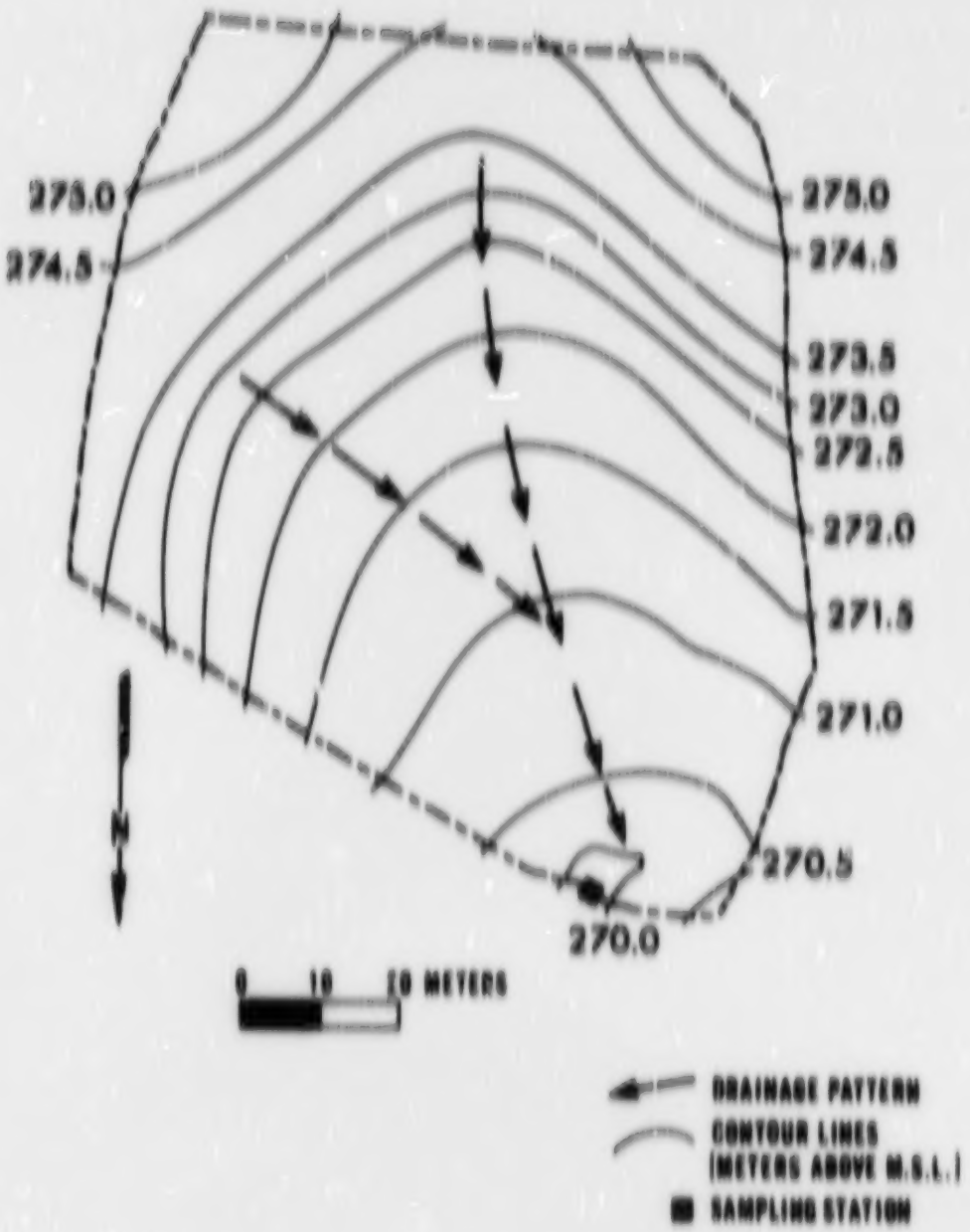

Figure 3 P6 Watershed, East Lansing, Michigan (0.8 ha)

fertilizer applications prior to planting and six weeks following. Table 1 lists the fertilizer application dates and amounts. The P2 watershed has an average slope of 2.5% and is comprised of Cecil sandy loam. The P6 watershed has a 6% slope with a variety of soil types including Spinks sandy loam and Travers, Hillsday, and Tuscola loam. Minimum tillage practices were followed on both watersheds with tillage operations performed only prior to planting.

TABLE 1. FERTILIZER APPLICATIONS ON THE P2 AND P6 WATERSHEDS IN 1974

Watershed	Date	N (kg/ha)	P (kg/ha)
P2 Watershed	4/29/74 (planting)	30	33
	6/11/74	112	-
P6 Watershed	5/29/74 (planting)	60	93
	7/8/74	130	-

SECTION 4.0

NUTRIENT SIMULATION RESULTS

The NPS Model was applied to each of the watersheds described in Section 3.0 for the period of available nutrient data. Monthly potency factors for various nutrient forms were calculated from the observed data. These initial values for the potency factors were adjusted slightly to improve agreement between simulated and observed nutrient washoff. The simulation results are discussed below for each watershed.

THIRD FORK CREEK, DURHAM, N.C.

Runoff, sediment, and nutrient loadings for Third Fork Creek were simulated for an 18-month period from October 1971 through March 1973. Simulated loadings of sediment (measured as Total Solids), TKN, Total P, and Fe are shown in Figure 4 and listed in Table 2. The hydrologic and sediment calibration was discussed in the NPS Model report and will not be repeated here. The variation in sediment and nutrient loadings shown in Figure 4 reflects the use of sediment as a pollutant indicator in the NPS Model. Since only selected storms were sampled on Third Fork Creek during the 18-month period, observed monthly loading values were not available for comparison with the simulation results. However, Colston (10) did estimate the 1972 pollutant loadings from regression equations developed from data on the 36 sampled storm events and extended to all 66 events that occurred on Third Fork Creek in 1972. The predicted loadings were then adjusted to correct a bias in the automatic sampling technique due to location of the equipment at the streambed. Because Third Fork Creek experiences a groundwater contribution, the pollutant loadings of the baseflow were estimated from analysis of periodic grab samples. Table 3 compares the NPS Model simulated pollutant loadings for 1972 with Colston's estimates. Since the NPS Model simulates only surface pollutant contributions, the simulated values should be compared with the storm runoff estimates. Except for TKN the simulated loadings are within 20% of Colston's estimates. This agreement is reasonably good considering the bias in the sampling technique, the regression method of estimation used by Colston, and the effects of in-stream processes and groundwater contributions neglected in the NPS Model. The over-simulated TKN loading is partially a result of calibrating the NPS Model potency factors with the storm-event data (discussed below). Over 50% of the total annual TKN loading originates from baseflow, according to Colston's estimates. Consequently, potency factors calibrated on storm events which include both surface runoff and groundwater would over-estimate the surface runoff contribution. Subsurface and groundwater flow paths appear to be significant for TKN

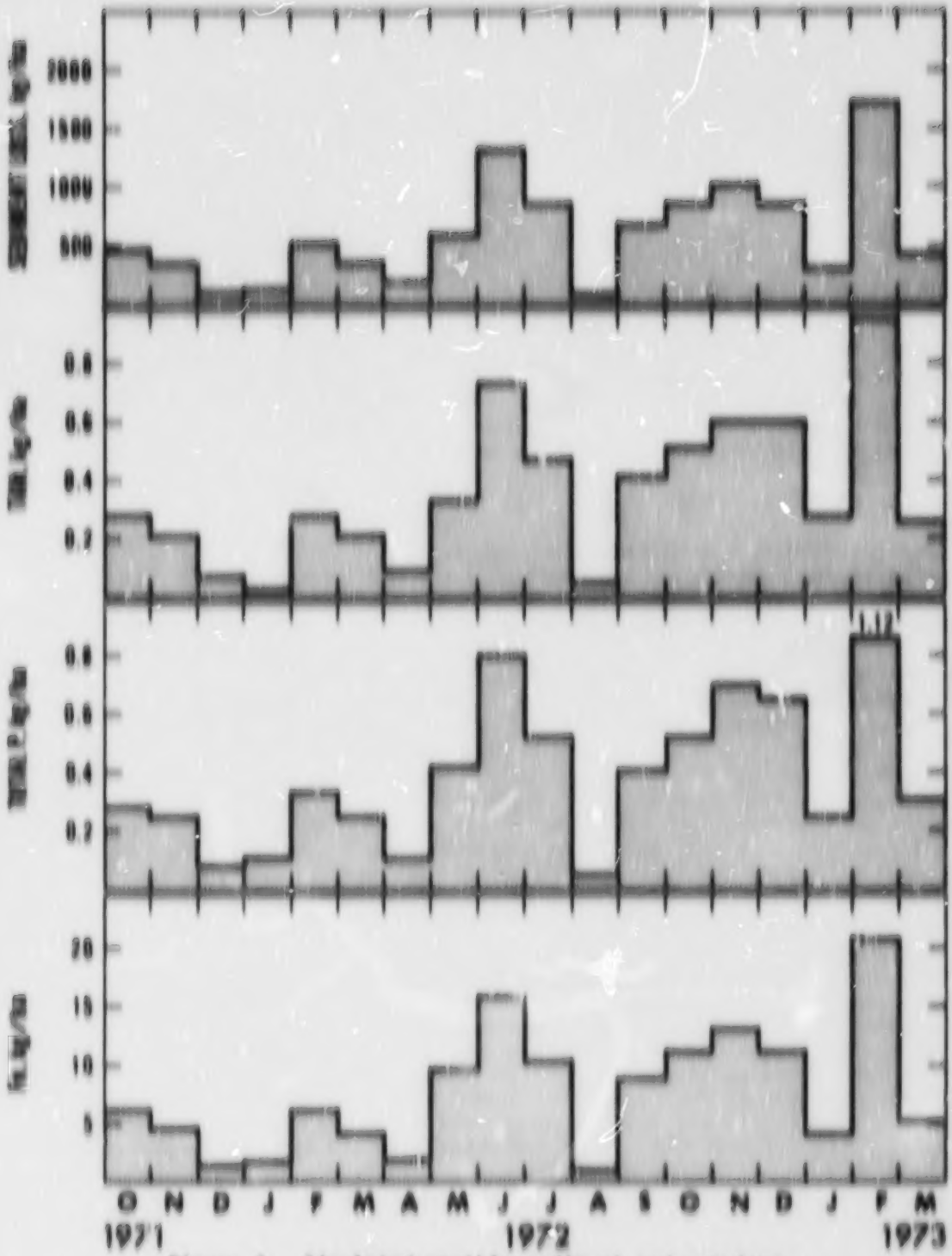

Figure 4. Simulated monthly sediment and nutrient loss from Third Fork Creek.

TABLE 2. SIMULATED MONTHLY SEDIMENT AND NUTRIENT LOSS FROM THIRD FORK CREEK

Month	Sediment kg/ha	TKN kg/ha	Total P kg/ha	Fe kg/ha
1971				
October	473	0.28	0.28	6.15
November	352	0.21	0.25	4.58
December	105	0.07	0.08	1.36
1972				
January	133	0.12	0.11	1.73
February	513	0.28	0.33	6.15
March	353	0.21	0.25	4.23
April	154	0.09	0.11	1.85
May	597	0.33	0.42	7.16
June	1326	0.73	0.80	15.91
July	861	0.47	0.62	10.33
August	90	0.05	0.05	1.09
September	686	0.41	0.41	8.91
October	858	0.51	0.52	11.15
November	1002	0.60	0.70	13.02
December	860	0.60	0.68	11.18
1973				
January	314	0.28	0.25	4.08
February	1730	0.95	1.12	20.76
March	439	0.26	0.31	5.26
Total	10846	6.46	7.16	134.90
Total for 1972	7433	4.40	4.87	92.71

loadings in Third Fork Creek; these contributions are not evaluated in the NPS Model.

TABLE 3. 1972 ANNUAL POLLUTANT LOADINGS IN URBAN RUNOFF FROM THIRD FORK CREEK (kg/ha)

	Estimated by Colston (10) Total	Base Flow	Storm Runoff	NPS Model Simulation Surface Runoff	% Difference[a]
Sediment	8024	672	7952	7433	-6.5
TKN	6.8	3.7	3.1	4.4	+41.9
Total P	5.3	1.0	4.3	4.9	+14.0
Fe	114.5	2.5	112	92.7	-17.2

[a] % Difference = $\frac{\text{NPS Model Simulation} - \text{Storm Runoff from Colston}}{\text{Storm Runoff from Colston}} \times 100\%$

Figures 6 through 14 present simulated and recorded data for five of the storms used in calibrating the nutrient potency factors on Third Fork Creek. Runoff and sediment loss for each storm are included in Figures 6, 7, 9, 11, and 13 to provide a basis for evaluating the nutrient simulation results. TKN, total P, and Fe simulation results are shown in Figures 8, 8, 10, 12, and 14, except Fe was not measured in the storm of October 5, 1972 (Figure 14). Although the NPS Model simulates all streamflow components (surface runoff, interflow, groundwater), only surface pollutant loadings are evaluated. Also, in-stream processes are not considered in the model although such processes do occur in the Third Fork Creek watershed. (The possible impact of in-stream processes was discussed in the NPS Model report). These factors should be kept in mind when reviewing the simulation results.

Analysis of the results for Third Fork Creek indicate the following points:

(1) Total P and Fe concentrations are relatively close to recorded values for the majority of the storms. Also, the shape of the Total P and Fe curves is similar to the sediment curve indicating sediment as the significant transport medium.

(2) TKN concentrations show considerable variation from storm to storm. For the January 10 storm (Figure 8), the shape of the TKN curve is similar to the sediment curve (Figure 5) but the recorded values are twice the simulated TKN values. Since the same potency factor is used for all storms that occur in the same month, the remaining data for January did not warrant increasing the potency factor. Baseflow samples on January 5, January 19, and January 26 contained TKN concentrations of 1.2, 2.9, and 2.9 mg/l respectively. Also similar measurements during November and December 1971 produced TKN concentrations of up to 9.0 mg/l. These values are generally much higher than ones observed during storm events. Colston noted that the high TKN concentrations in two December 1971 storms were believed to

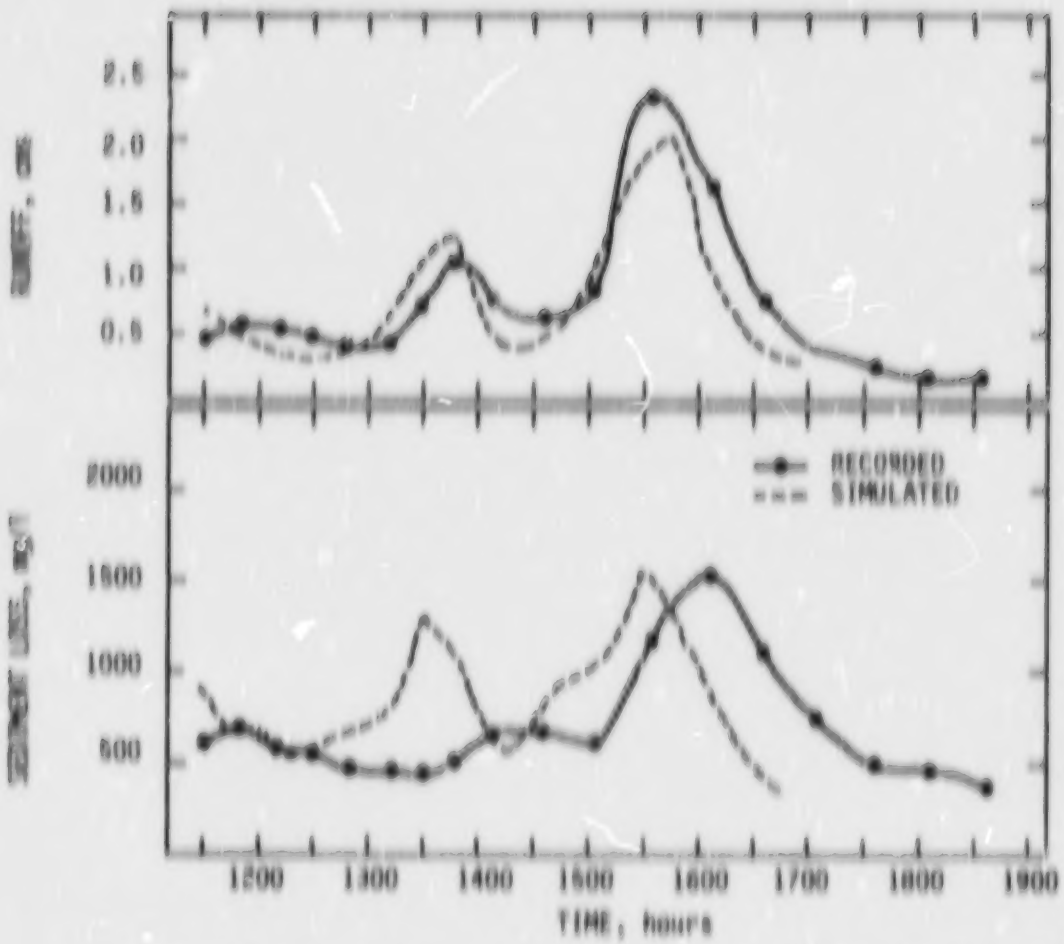

Figure 6. Runoff and sediment loss for Third Fork Creek for the storm of January 10, 1972.

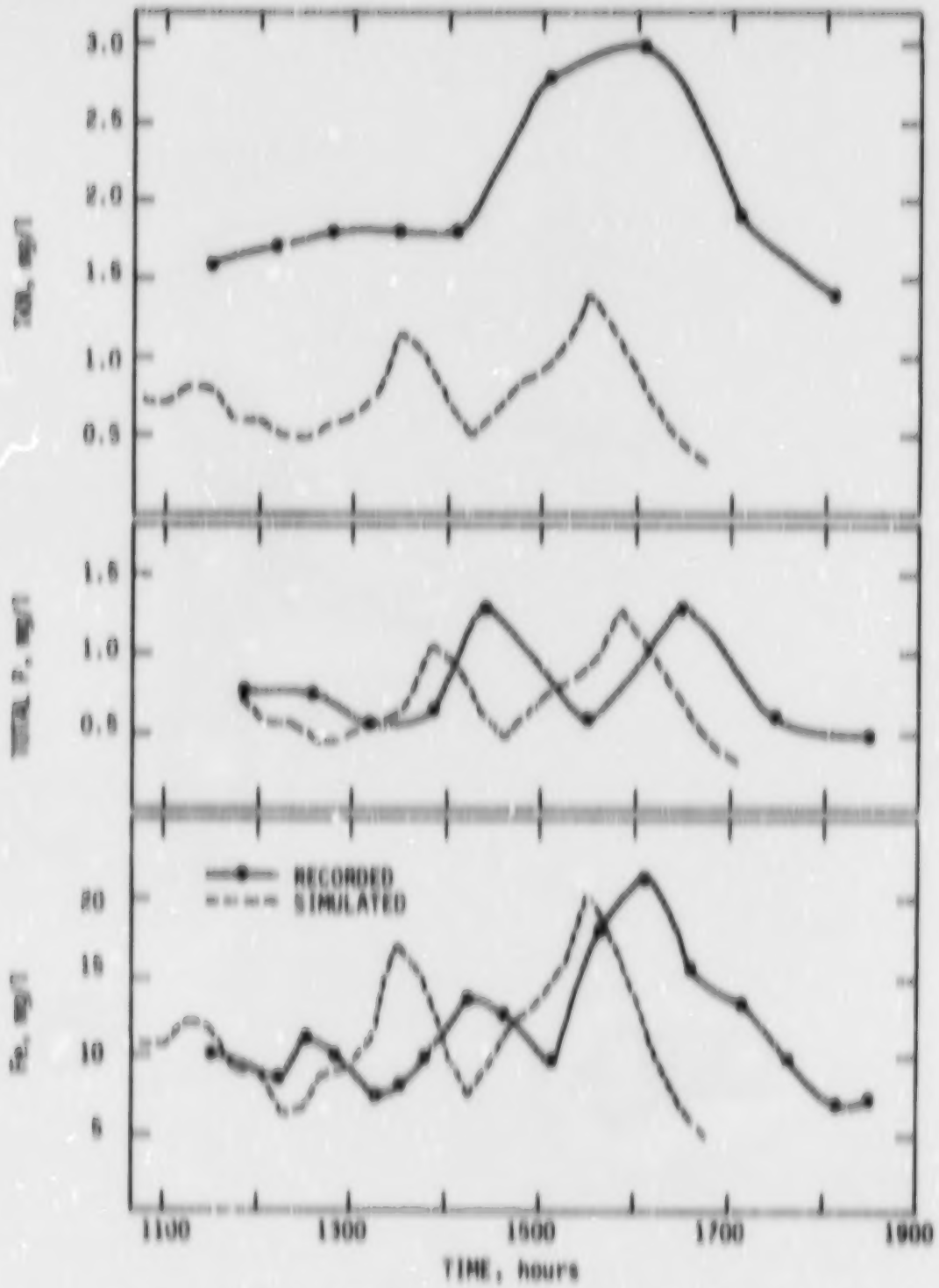

Figure 6. TKN, total P, and Fe concentrations for Third Fork Creek for the storm of January 16, 1972.

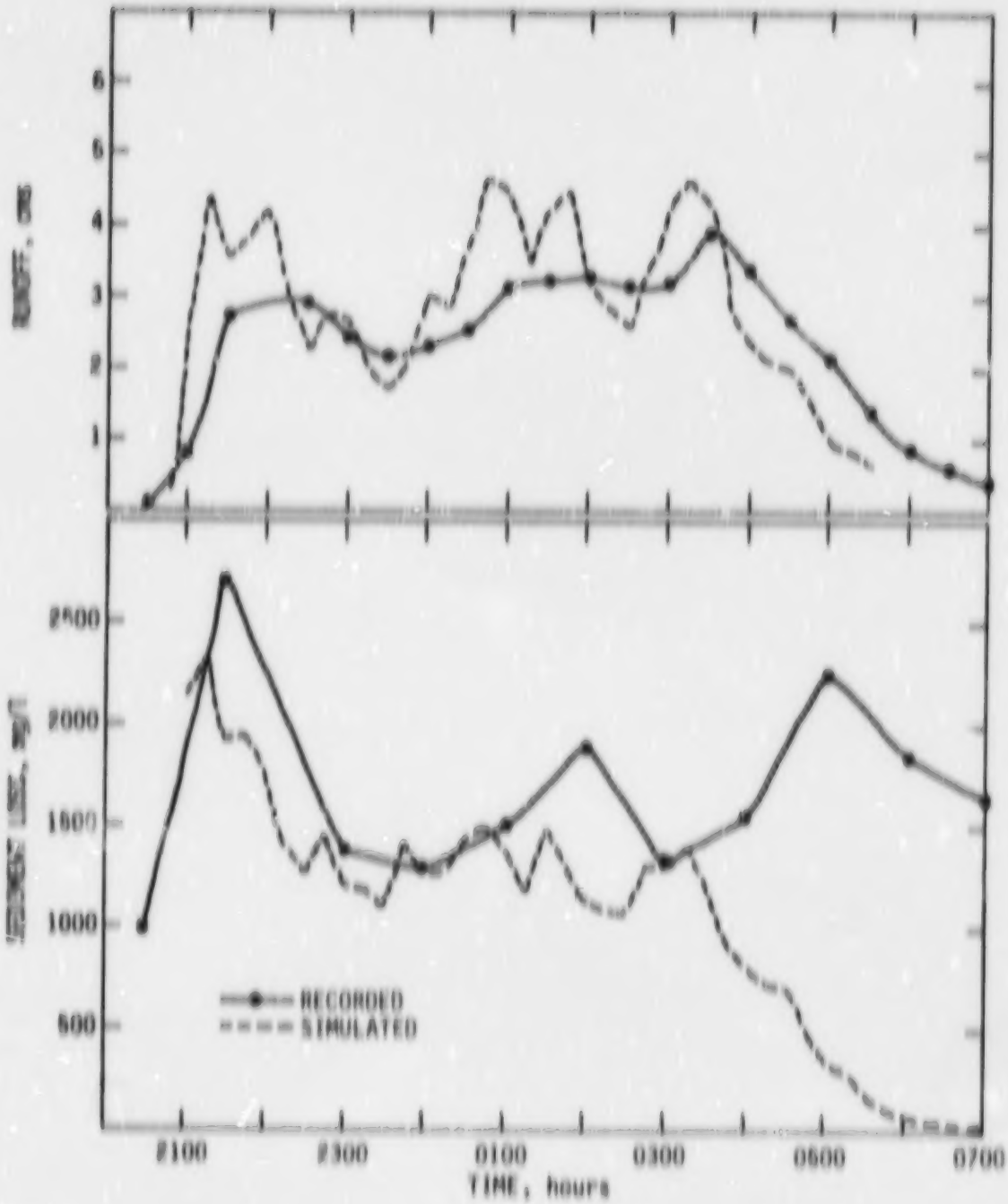

Figure 7. Runoff and sediment loss for Third Fork Creek for the storm of February 1, 1972.

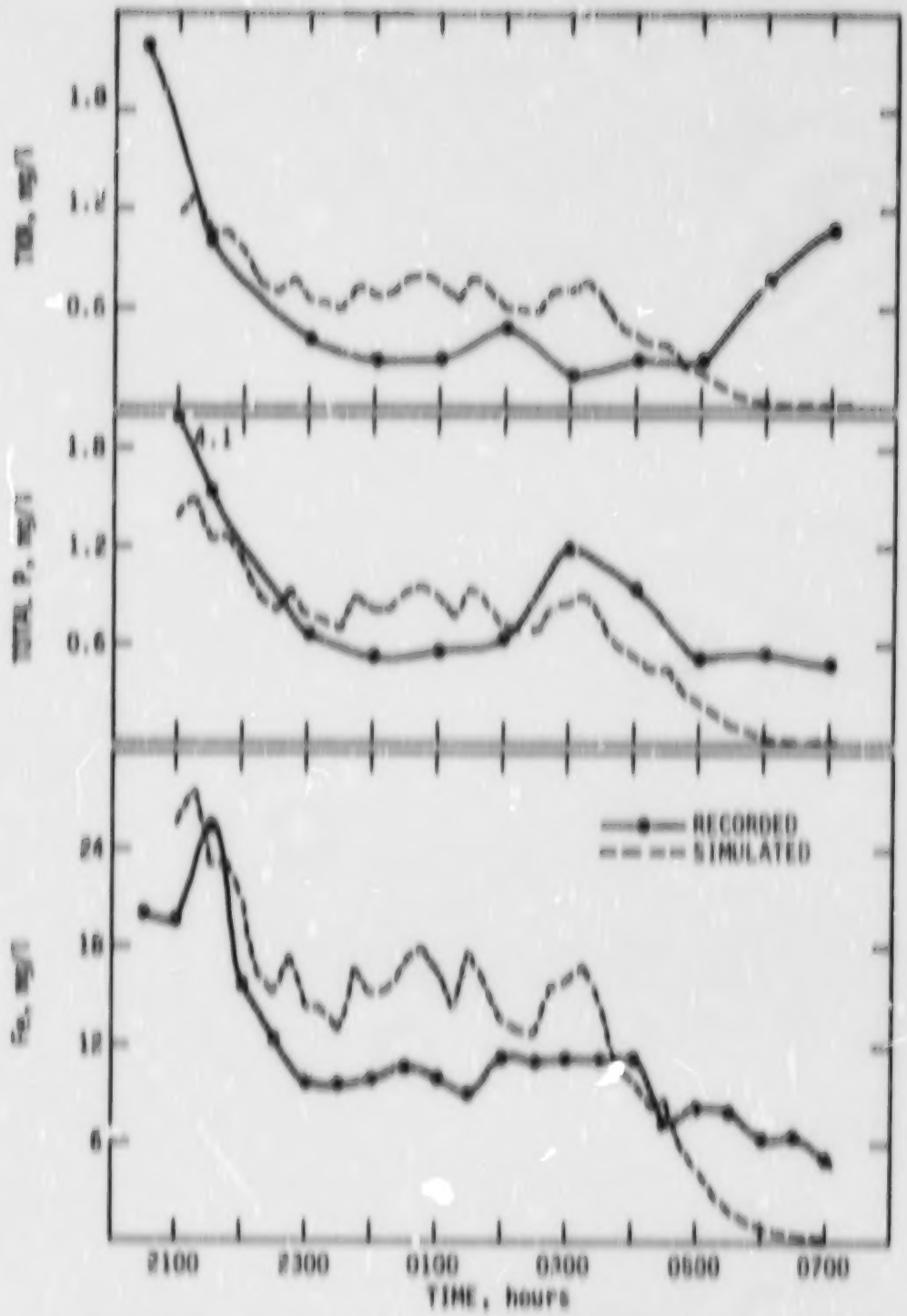

Figure 8. TKN, Total P, and Fe concentrations for Third Fork Creek for the storm of February 1, 1978.

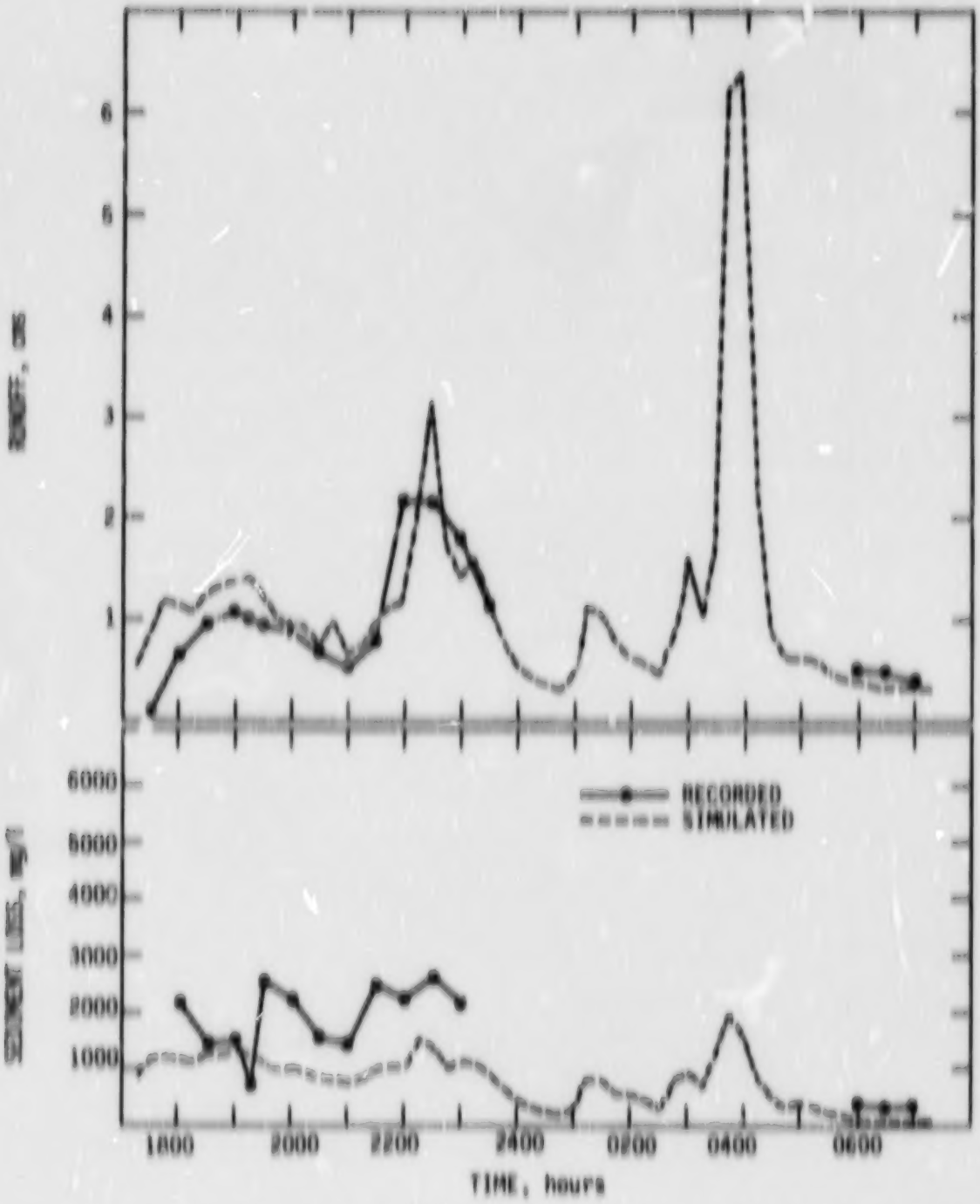

Figure 9. Runoff and sediment loss for Third Fork Creek for the storm of February 12, 1972.

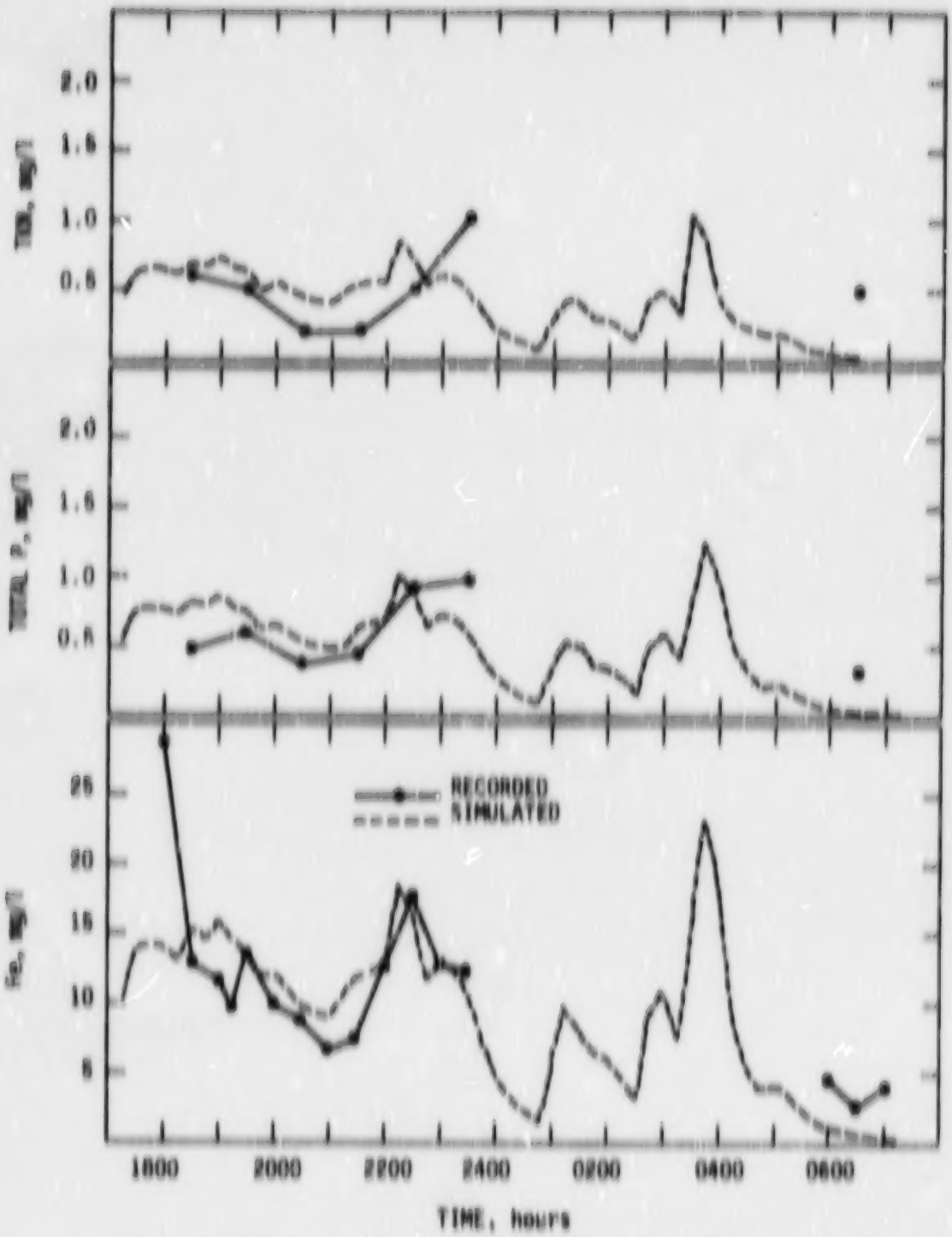

Figure 10. TKN, Total P, and Fe concentrations for Third Fork Creek for the storm of February 12, 1972.

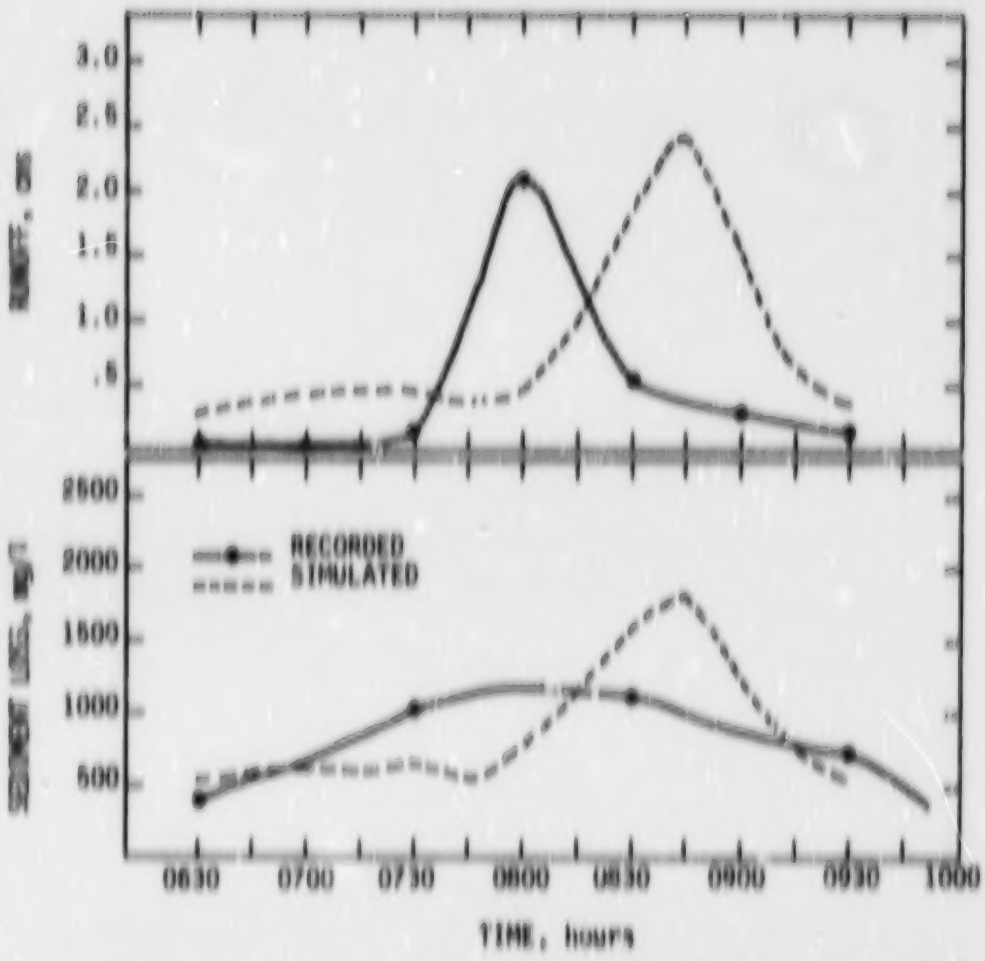

Figure 11. Runoff and sediment loss from Third Fork Creek for the storm of June 20, 1972.

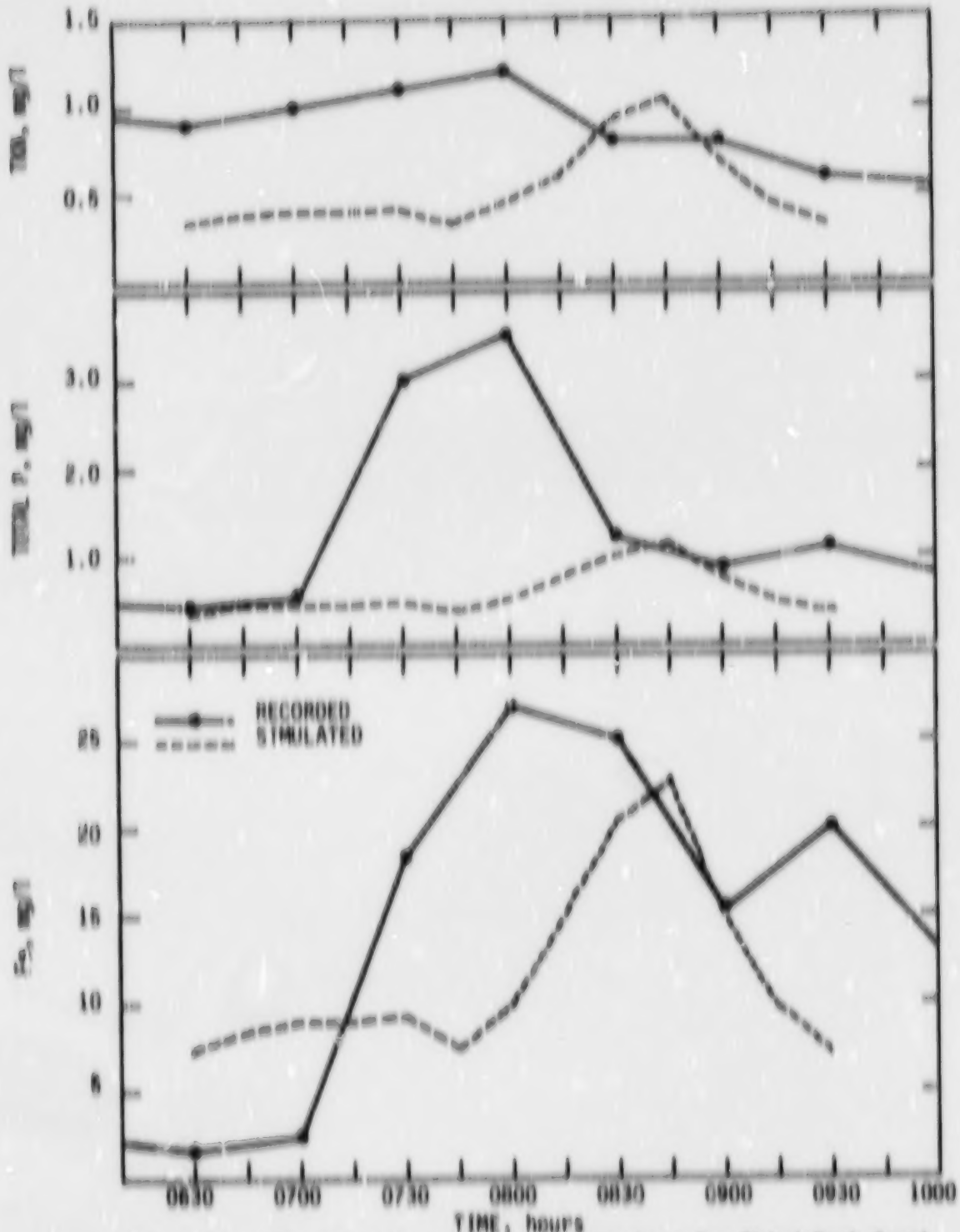

Figure 12. TKN, Total P, and Fe concentrations for Third Fork Creek for the storm of June 20, 1972.

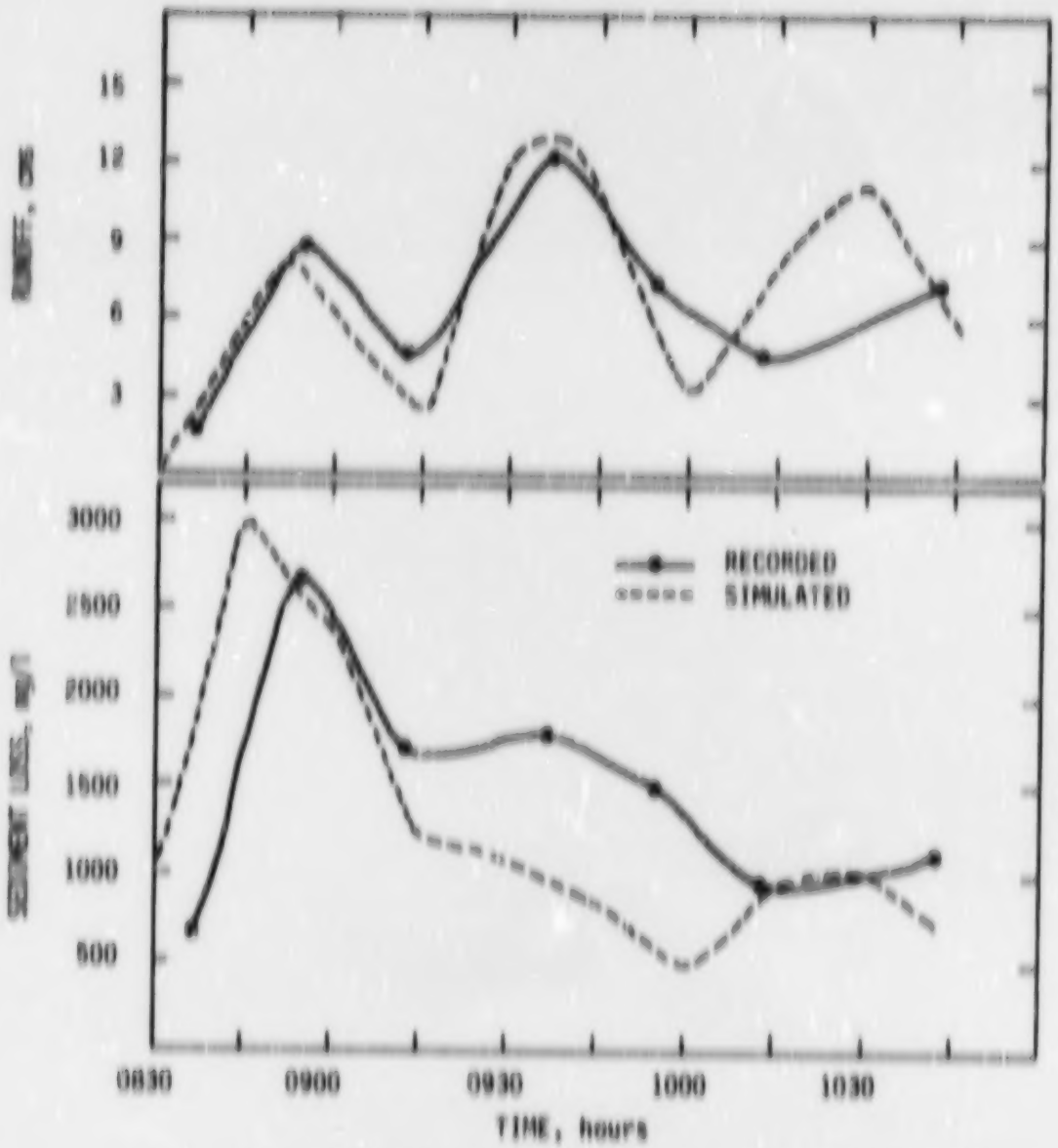

Figure 13. Runoff and sediment loss for Third Fork Creek for the storm of October 5, 1972.

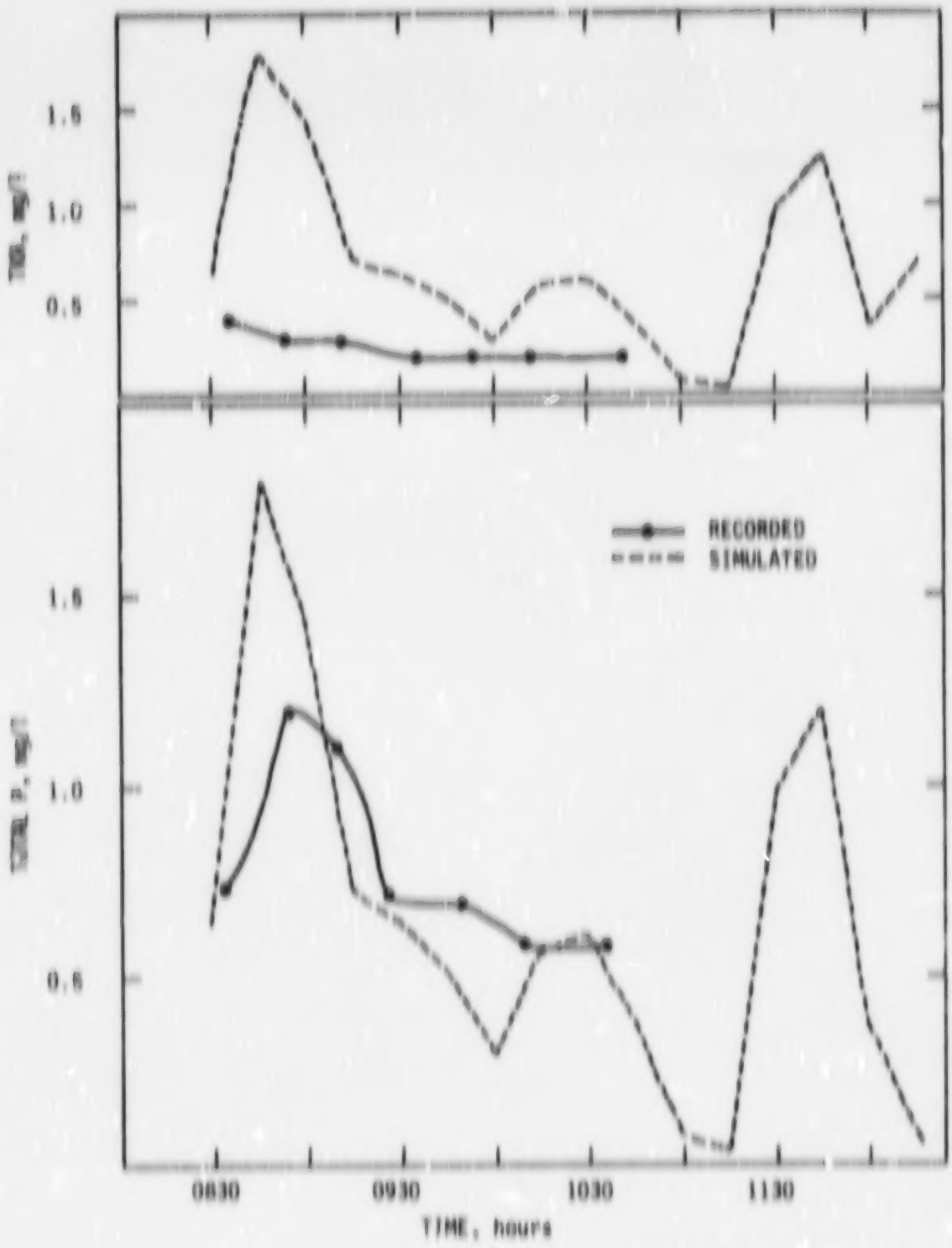

Figure 14. TKN and Total P concentrations for Third Fork Creek for the storm of October 5, 1972.

be erroneous. Thus, the high recorded values for January 10 could be due to unusual conditions and/or sampling/analysis errors.

(3) The TKN concentrations during February storms (Figures 8 and 10) are well represented by the simulation. Since the storms occur in the same month, the same potency factor for TKN was used. On the other hand, the October 5 storm (Figure 14) produced TKN concentrations reminiscent of baseflow; very little variation was recorded throughout the storm. Consequently, the simulated and recorded TKN concentrations for the October storm differ considerably with no apparent explanation.

(4) The February 1 storm (Figure 8) shows the impact of baseflow pollutant contributions. High TKN concentrations occurred at the beginning and end of the storm when flow was minimal and likely originating from subsurface and groundwater sources. Since baseflow TKN concentrations were high during this period (1.0 to 1.6 mg/l), the effect of the storm runoff was to dilute the baseflow contribution.

(5) The simulation results for the June 20 storm (Figures 11 and 12) demonstrate a number of problems that should be noted when comparing simulated and observed values. The runoff volume and peak flow are reasonably close except for a 1½ hour discrepancy in the timing of the peak. Unless such differences occur consistently throughout the simulation period, they can usually be assigned to errors in the recorded time of either the input precipitation or the observed streamflow. Although the recorded sediment data does not closely correspond to the simulated values, the major reason for this is the lack of observed data points between 7:30 and 8:30 when the peak flow occurred. Total P, Fe, and suspended solids (not shown) had peak concentrations at 8:00; therefore, one would expect the sediment to behave in a similar fashion. A peak sediment concentration at 8:00 would have improved agreement between simulated and recorded values, although the timing error remains.

The nutrient simulation results for June 20 are similar to the results for the other storms except for greater differences between simulated and recorded values. Total P and Fe closely correspond to the "expected" sediment curves. The unusually high Total P concentrations are not substantiated in other summer storms; thus, the simulated values are low. The TKN concentrations show little variation with flow or sediment resulting in differences between the simulated and recorded values.

The simulation results for Third Fork Creek indicate the NPS Model, using sediment as a pollutant indicator, can reasonably represent Total P and Fe loadings from the land surface. Other constituents (e.g. micronutrients, heavy metals) behaving in a similar fashion would likely show similar accuracy. The TKN concentrations were not represented as well as Total P and Fe due in part to TKN concentrations in baseflow. Since pollutant concentrations in baseflow are less variable than in surface runoff, the NPS Model could be modified to allow input of monthly values for pollutant concentrations occurring in the baseflow. Such a modification would likely improve simulation results in watersheds where a groundwater flow component is present.

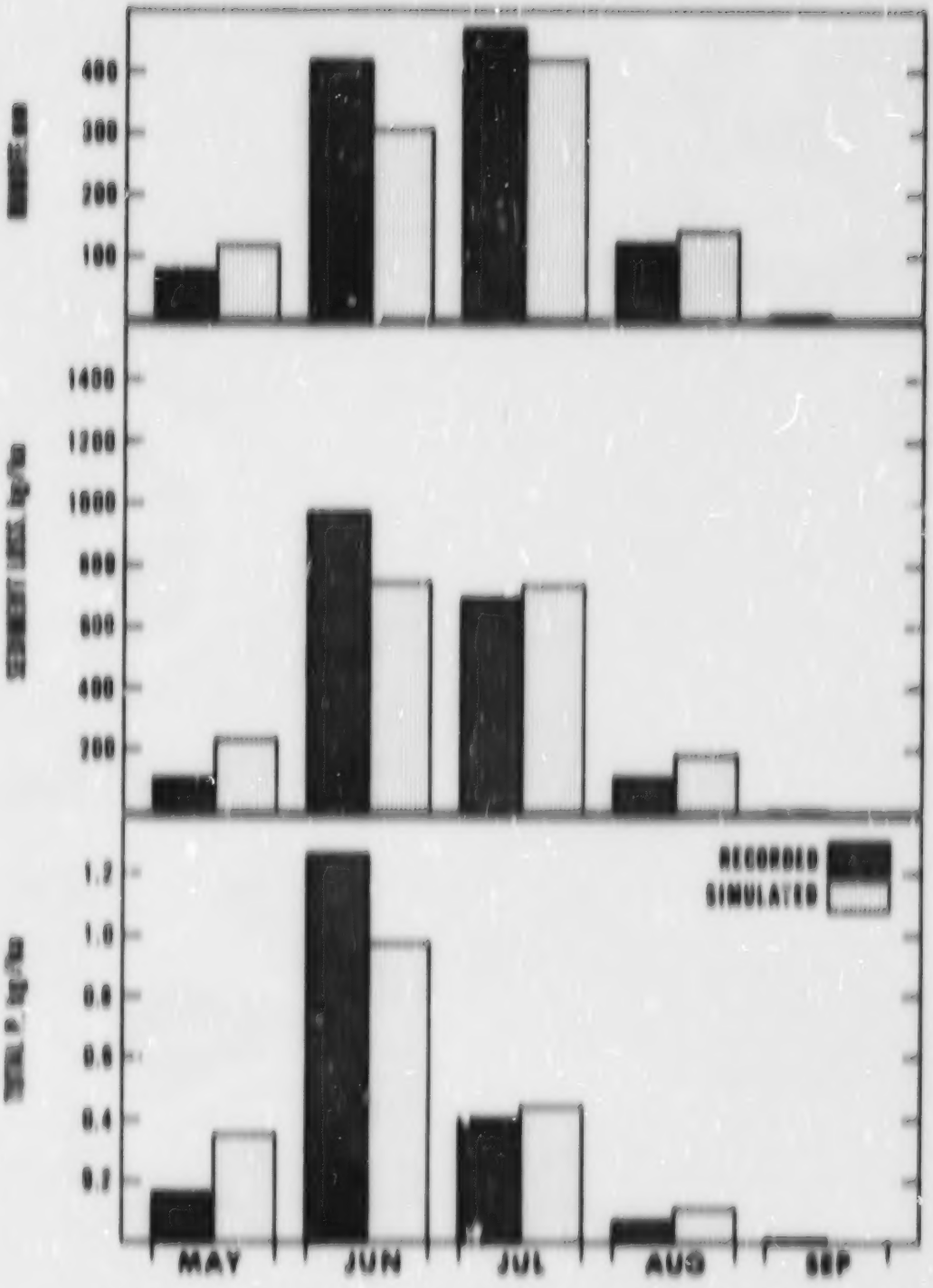

Figure 15. Monthly runoff, sediment and Total P loss from the PZ watershed (May-September 1974).

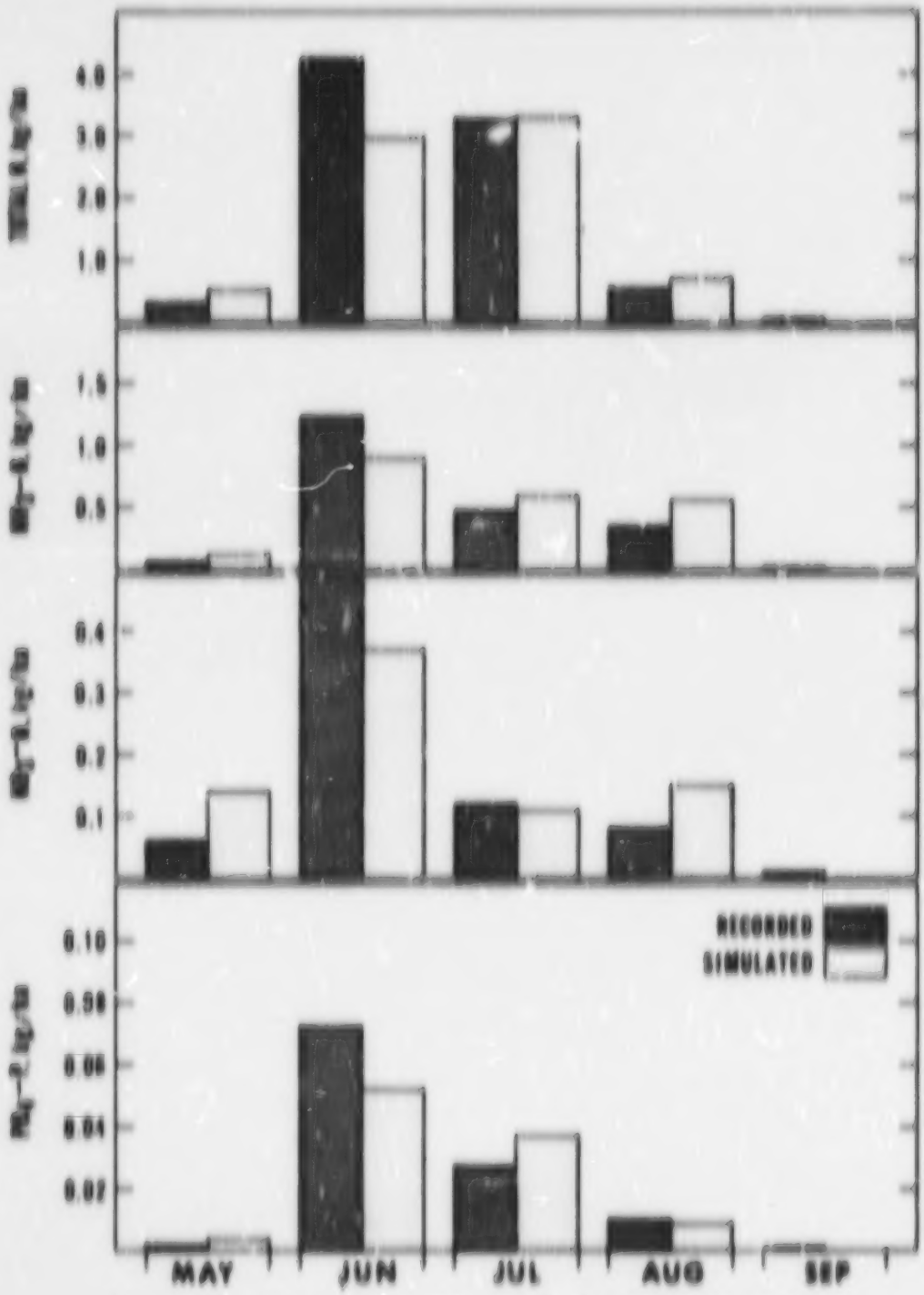

Figure 16. Monthly total N, NH_3-N, NO_3-N and PO_4-P loss from the P2 watershed (May-September 1974).

P2 WATERSHED, WATKINSVILLE, GEORGIA

Nutrient loadings from the P2 watershed were simulated with the NPS Model for the 1974 growing season (May through September). Simulated and recorded monthly runoff, sediment, and nutrient loadings are shown in Figures 15 and 16, and listed in Table 4. The initial runoff and sediment parameters were obtained from modeling work on nearby watersheds (12) and slightly adjusted to better represent the recorded runoff and sediment

TABLE 4. SIMULATION RESULTS AND RECORDED DATA FOR THE P2 WATERSHED
(May - September 1974)

Month		Runoff mm	Sediment kg/ha	Total P kg/ha	Total N kg/ha	NH_4-N kg/ha	NO_3-N kg/ha	PO_4-P kg/ha
May	Rec.	77.	103.	0.16	0.31	0.06	0.06	.002
	Sim.	118.	235.	0.35	0.62	0.12	0.14	.004
June	Rec.	418.	972.	1.26	4.24	1.23	0.49	.072
	Sim.	307.	742.	0.97	2.97	0.89	0.37	.062
July	Rec.	470.	687.	0.40	3.27	0.46	0.12	.027
	Sim.	420.	734.	0.44	3.30	0.51	0.11	.037
August	Rec.	122.	105.	0.07	0.53	0.34	0.08	.010
	Sim.	142.	186.	0.11	0.71	0.56	0.15	.009
September	Rec.	6.	1.	0.01	0.02	0.01	0.01	.001
	Sim.	0.	0.	0.	0.	0.	0.	0.
Total	Rec.	1093.	1867.	1.90	8.36	2.09	0.76	0.112
	Sim.	987.	1898.	1.87	7.60	2.15	0.77	0.101

during the summer period. The simulated nutrient values result from monthly potency factors derived from the recorded data. The potency factors were also modified slightly in calibration by comparing simulated and observed nutrient concentrations. The results indicate total P and total N loadings are more closely associated with the sediment fraction of surface runoff than the other nutrient forms. Improving the sediment simulation would improve both the total P and total N results. The simulated NH_4-N loadings would also improve with a more accurate sediment simulation, but the discrepancies between simulated and recorded loadings are somewhat greater than for total P and total N. These results are

verified by the recorded data which indicates 79% of Total P, 64% of Total N, and 32% of NH_3-N in surface runoff during the 1974 growing season was associated with sediment.

The recorded NO_3-N and PO_4-P values were measured only in the water portion of surface runoff because the fraction of these nutrient forms attached to sediment is usually small. Thus one would not expect accurate simulation of NO_3-N and PO_4-P loadings using sediment as an indicator. Any agreement in Figure 16 reflects the dependence of sediment loss on runoff which is the transporting mechanism for these nutrient forms. However, the recorded values indicate NO_3-N and PO_4-P loadings are a small portion of the Total N and Total P losses from the P2 watershed.

Analysis of the simulation results for individual storm events was the basis for calibration of the nutrient potency factors. Unfortunately the short period of available nutrient data provided few storms with detailed data for calibration. However, sufficient results were obtained to provide another evaluation of the NPS Model and the use of sediment as a nutrient runoff indicator. Figures 17 through 24 present the simulated and recorded values for four storm events on the P2 watershed during the 1974 growing season. The runoff, sediment loss, and total P concentrations are included in Figures 17, 19, 21, and 23, while the Total N, NH_3-N, NO_3-N, and PO_4-P concentrations are shown in Figures 18, 20, 22, and 24. Analysis of these results yields the following points:

(1) One problem in simulating the P2 watershed was the small size of the watershed in relation to the 15-minute simulation interval of the NPS Model. The steep rising limb of the recorded hydrographs could not be accurately represented in many cases where the short summer thunderstorms occurred in less than three or four simulation time intervals. However, except for some timing problems, the runoff volumes and peak flows are simulated reasonably well for the four storms.

(2) The sediment parameters were calibrated to improve agreement between simulated and recorded sediment concentrations. The results indicate the NPS Model can be calibrated to approximate sediment loss from agricultural watersheds. Although research is needed to more accurately represent the erosion process, sediment simulation with the NPS Model, as indicated by the results on the P2 watershed, is adequate for planning purposes.

(3) As noted above for the monthly loading values, Total P concentrations closely follow the sediment values. Better simulation of sediment would improve the Total P simulation. Thus the use of monthly potency factors in the NPS Model is a good assumption for simulating Total P loadings.

(4) Total N concentrations demonstrate some correlation to sediment but deviations do exist. The sediment and Total N curves for the storm of July 27 (Figures 21 and 22) are considerably different while the values for remaining storms show greater correspondence. For the latter events, an improved sediment simulation would improve the Total N simulation. Consequently, sediment is also a reasonable indicator for Total N loadings from the P2 watershed.

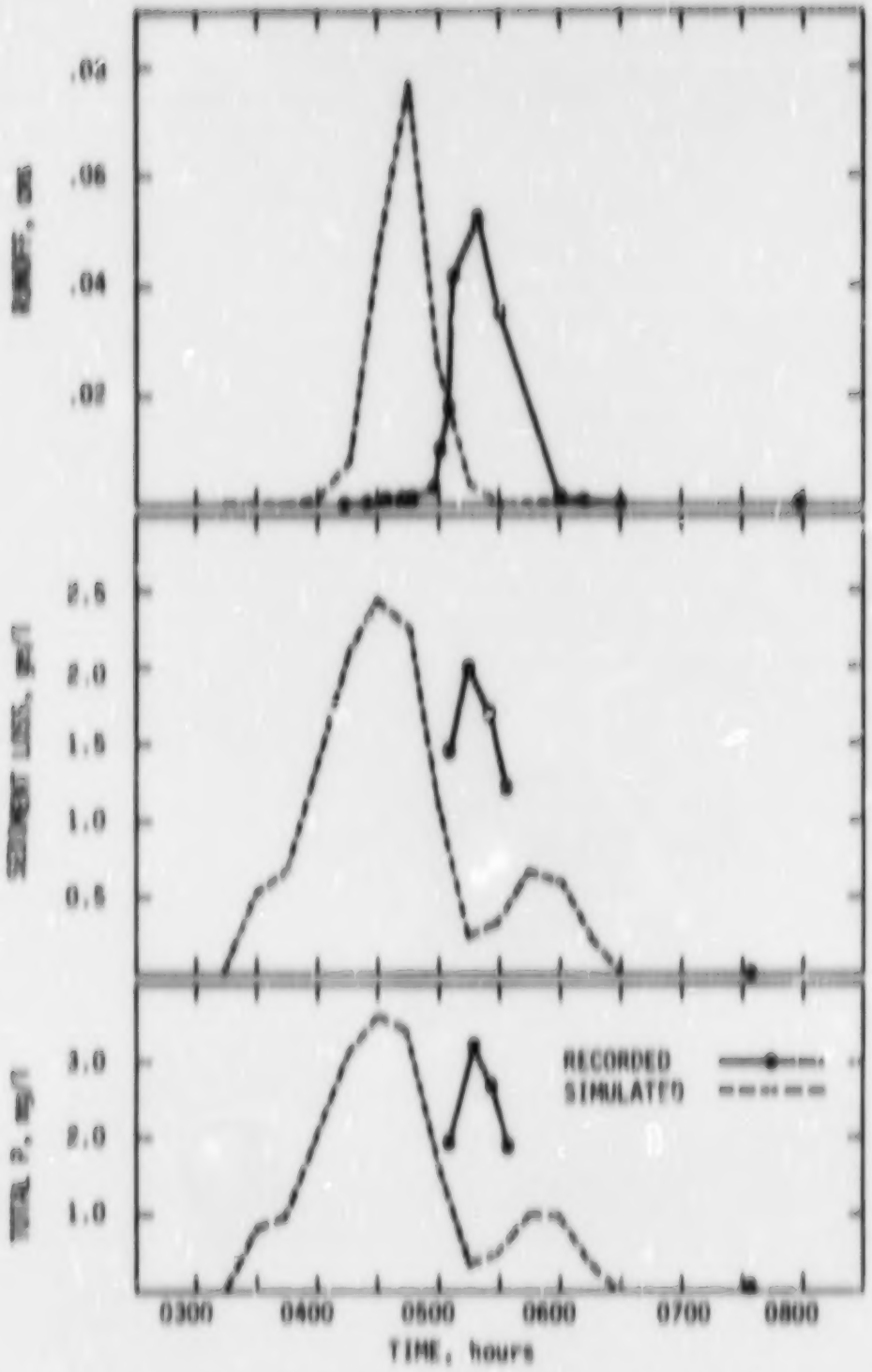

Figure 17. Runoff, sediment loss and Total P concentrations for the P2 watershed for the storm of May 23, 1974.

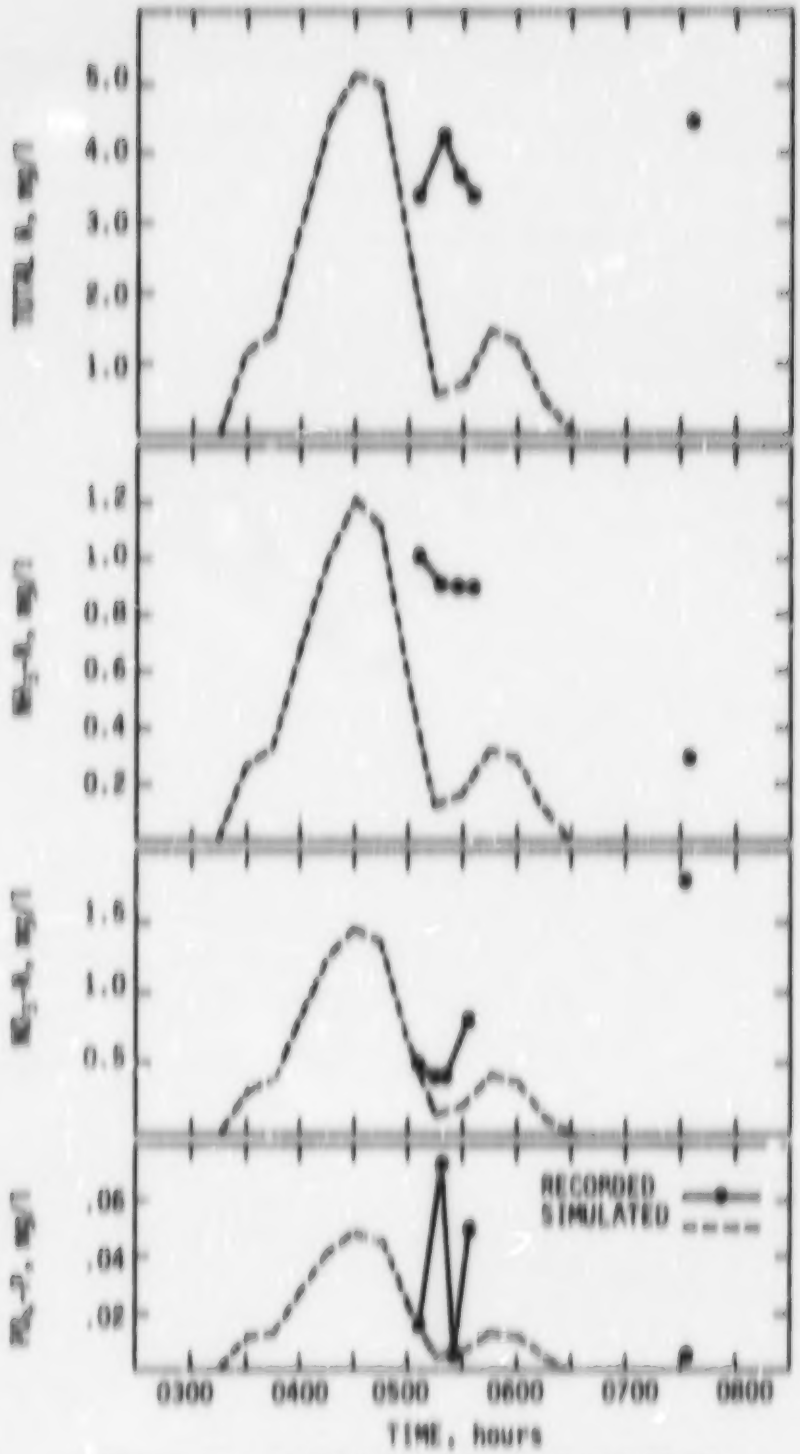

Figure 18. Total N, NH_3-N, NO_3-N and PO_4-P concentrations for the P2 watershed for the storm of May 23, 1974.

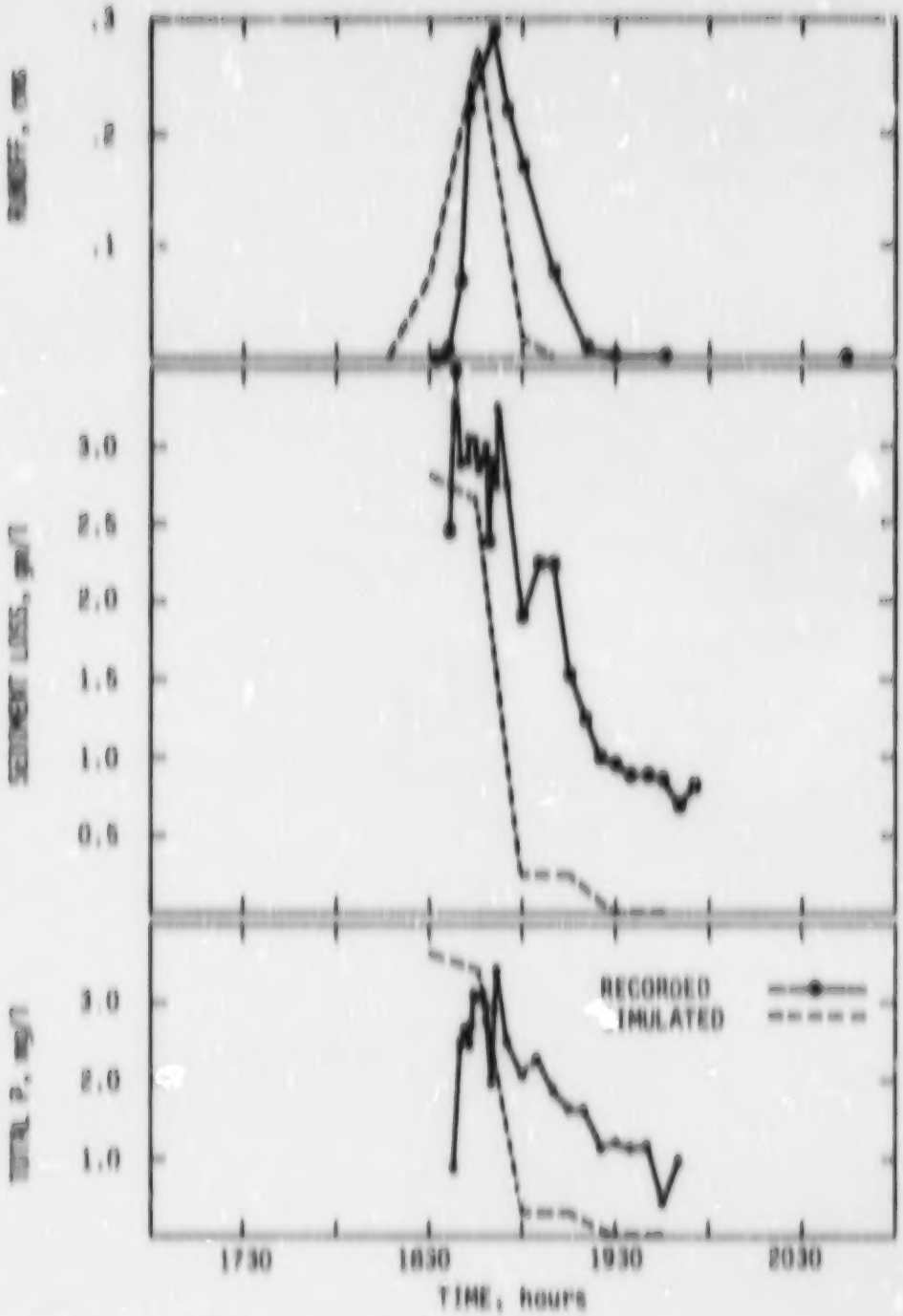

Figure 19. Runoff, sediment loss and total P concentrations for the P2 watershed for the storm of June 27, 1974.

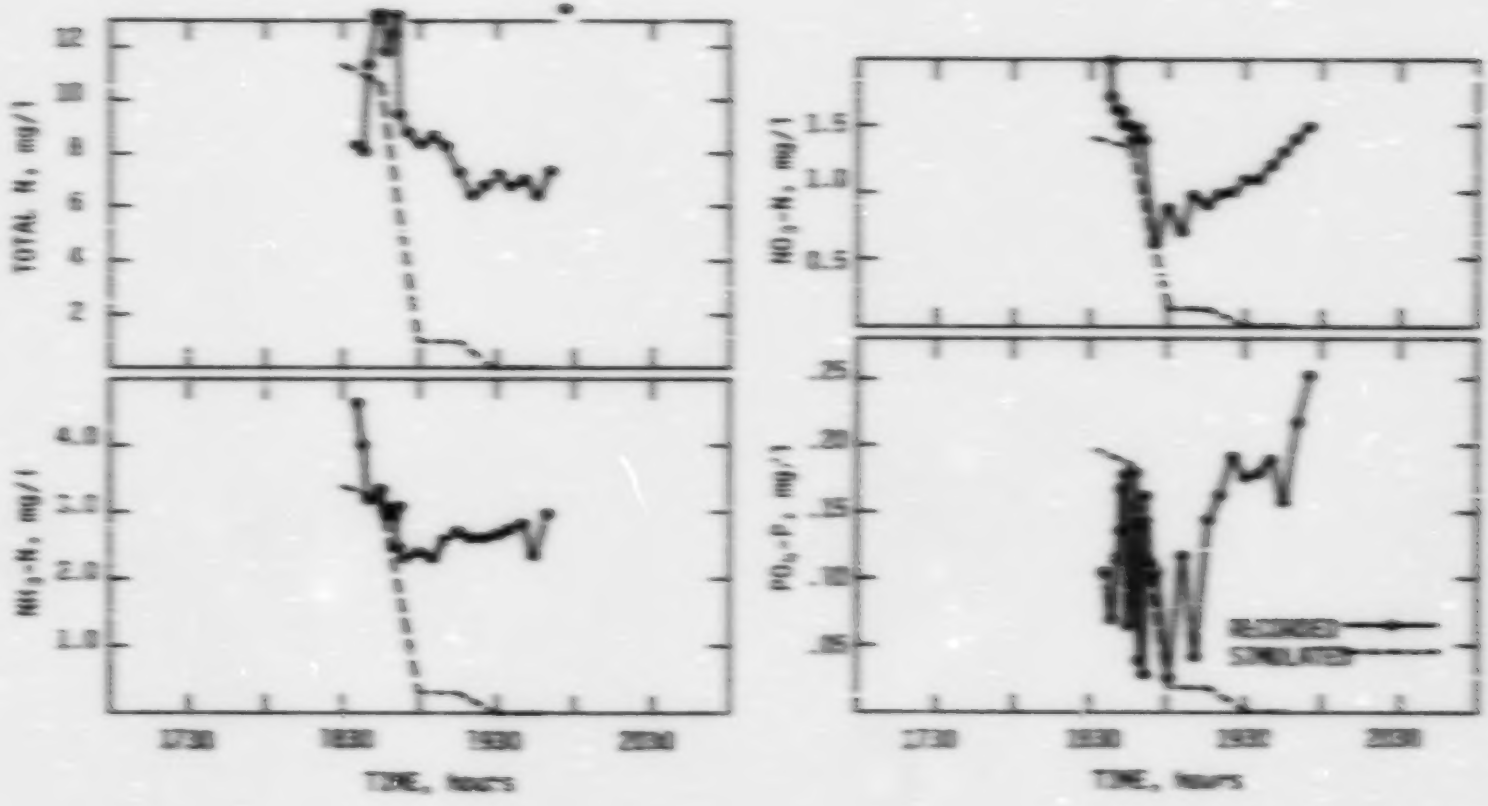

Figure 20. Total N, NH_3-N, NO_3-N and PO_4-P concentrations for the Ft
extended for the storm of June 27, 1974.

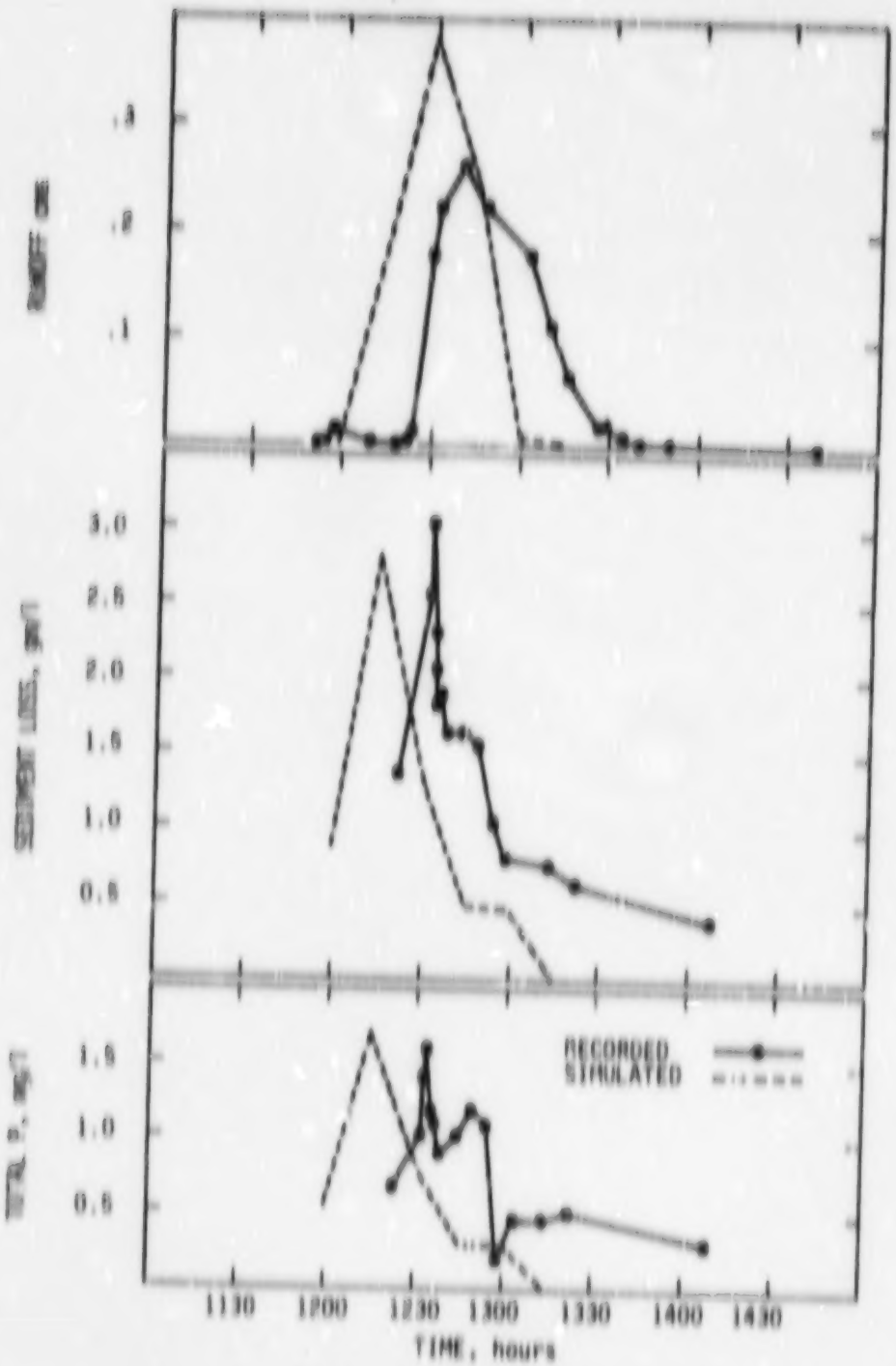

Figure 21. Runoff, sediment loss and total P concentrations for the C2 watershed for the storm of July 27, 1974.

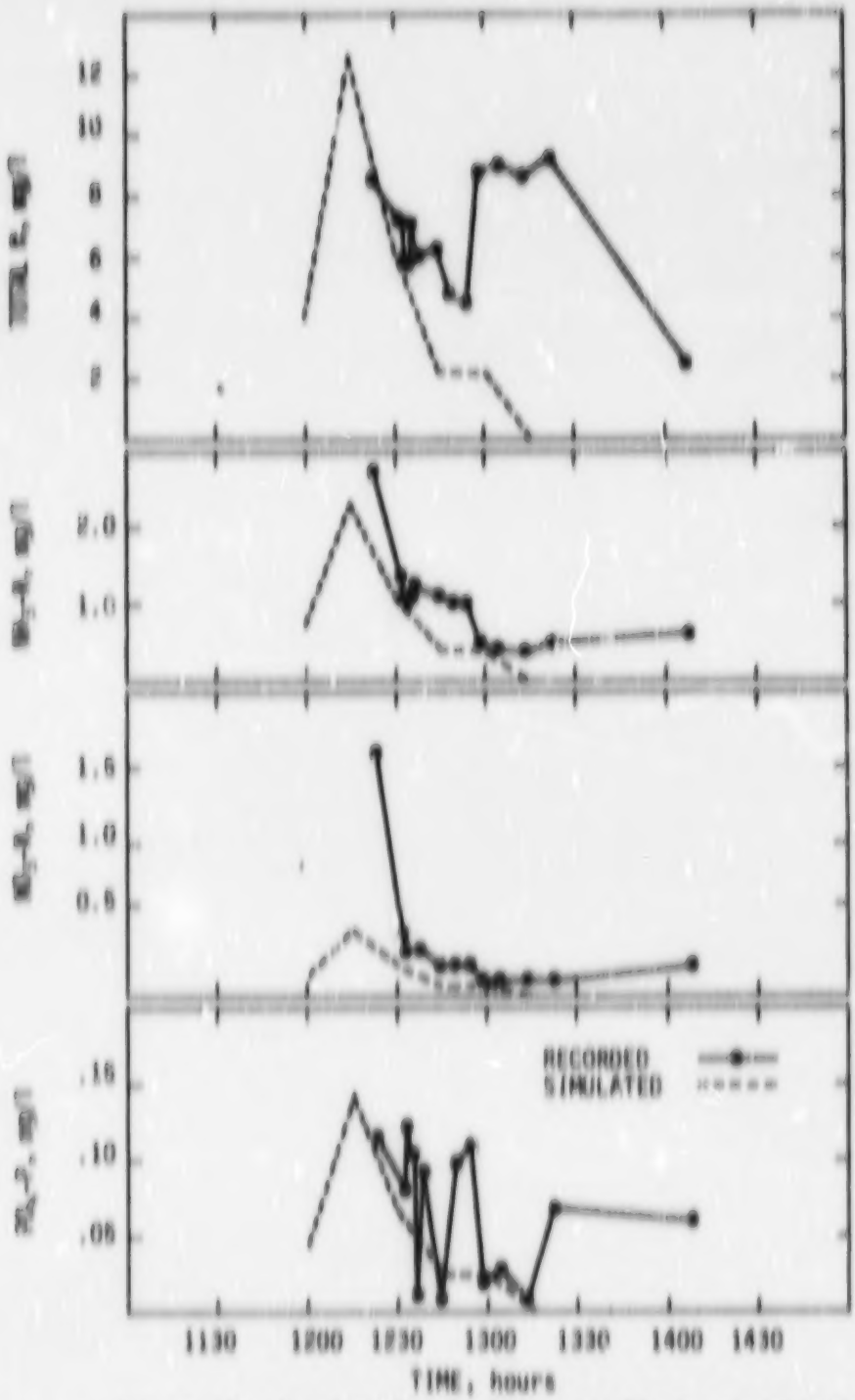

Figure 22. Total N, NH_3-N, NO_3-N and PO_4-P concentrations for the P2 watershed for the storm of July 27, 1974.

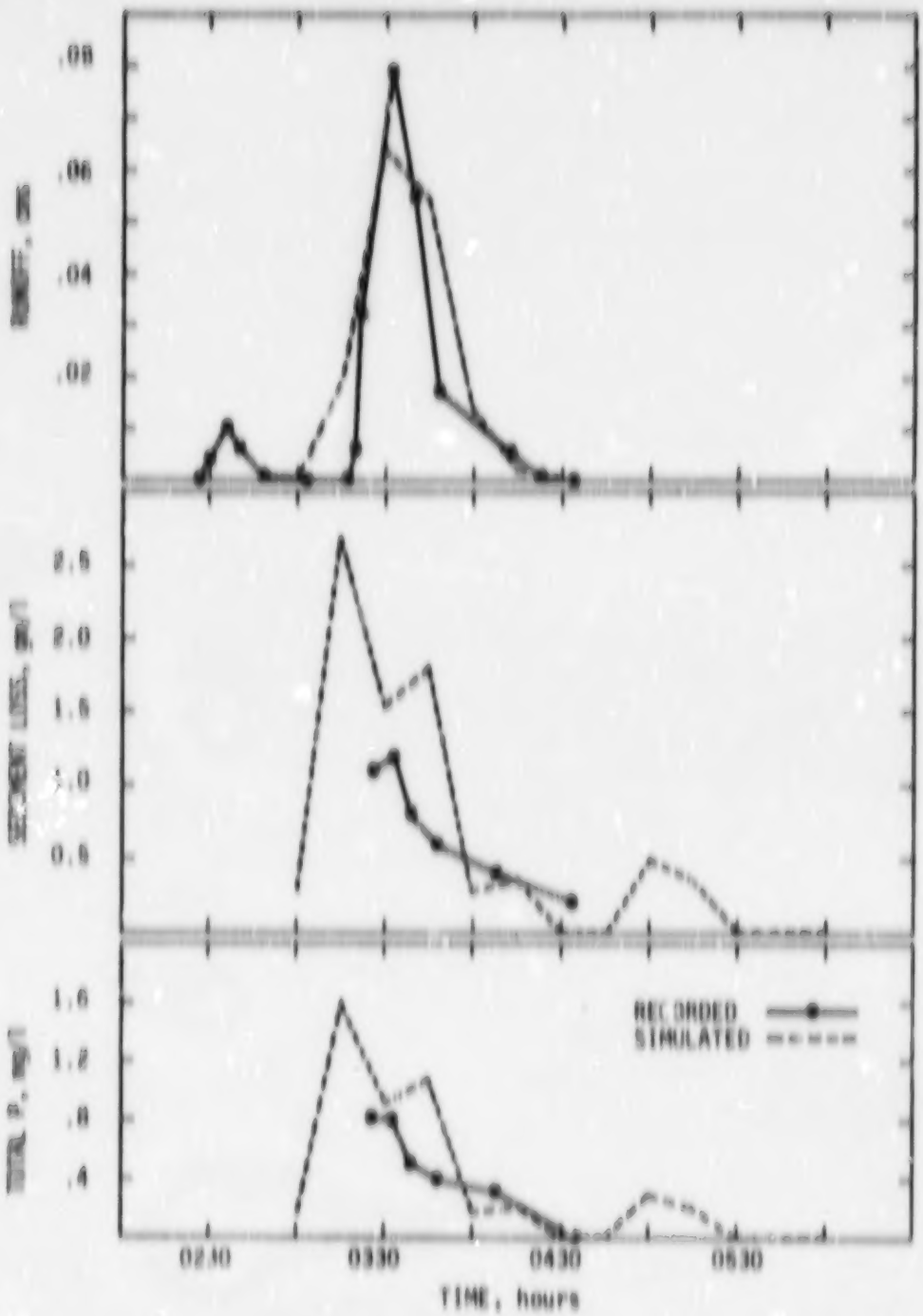

Figure 23. Runoff, sediment loss and total P concentrations for the P2 watershed for the storm of August 16, 1974.

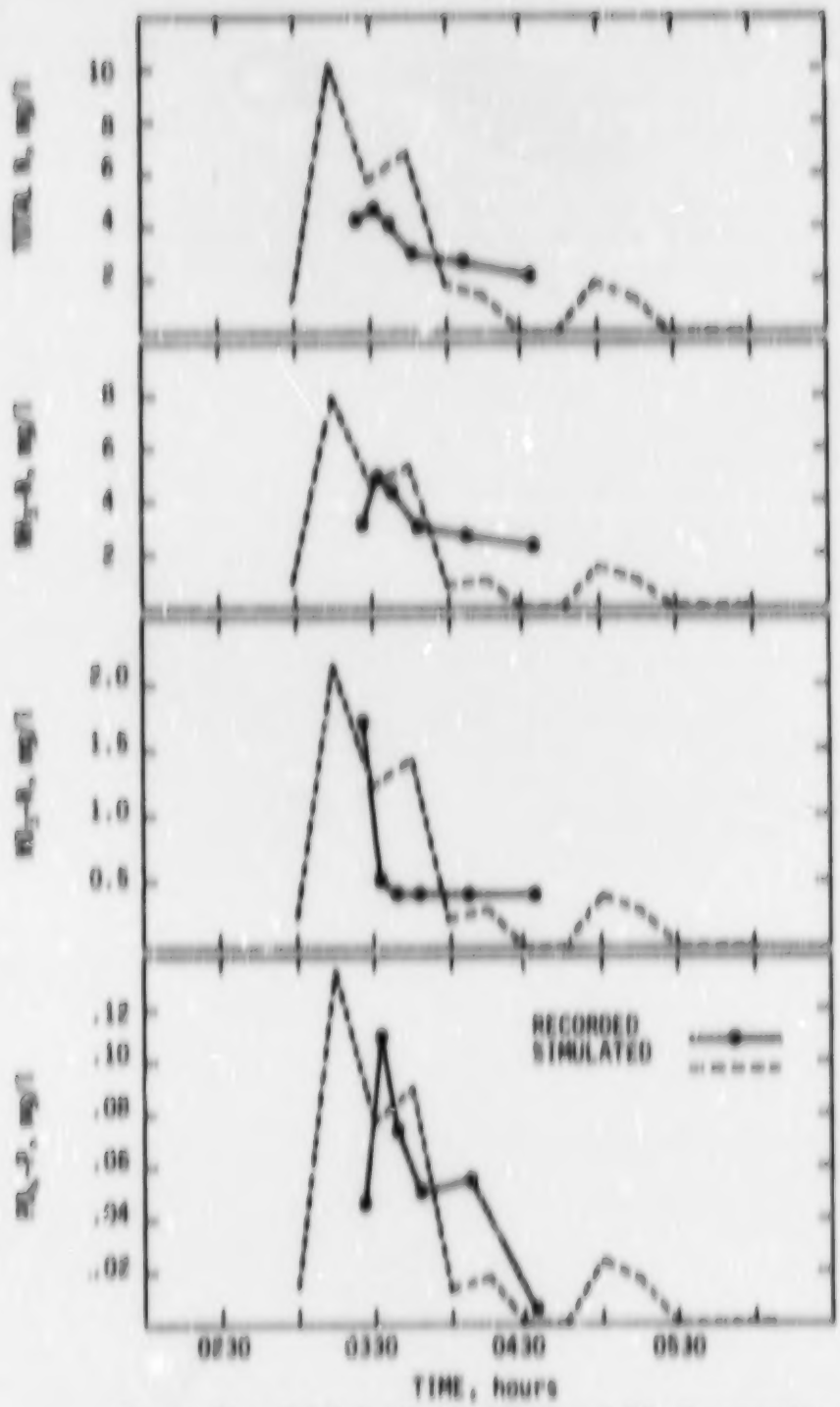

Figure 24. Total N, NH_4-N, NO_3-N and PO_4-P concentrations for the P2 watershed for the storm of August 16, 1974.

(5) For NH_3-N, the results are inconclusive. For some storm events, the NH_3-N concentrations are obviously influenced by the sediment values (Figures 21, 22, 23, and 24). In other cases, the NH_3-N concentrations are almost constant showing little variation with either flow or sediment loss. The recorded data on P2 demonstrates that it is transported both on sediment and in solution.

(6) The variations in NO_3-N and PO_4-P concentrations during storm events demonstrate little or no relationship to sediment concentration. In some cases, there appears to be an inverse relation to the flow rate. The extreme variations, especially for PO_4-P, are basically unexplained. They are likely due to instantaneous variations in sediment characteristics, areal variations in soil P concentrations, and relative amounts of surface and subsurface flow. In any case, high concentrations at low flow rates have little impact on the total storm nutrient load. Burwell, et al (14) found that neglecting such high concentrations had no significant impact on the calculated storm nutrient load when compared to an integrated method over the entire event. Thus, high concentrations occurring at low flow rates can be effectively neglected in the calibration process. This is demonstrated in Figure 18 where a concentration value is recorded two hours after the major portion of the storm event. Such concentrations are highly suspect because the value is an average concentration since the previous sample. With zero flow occurring between the samples, the last recorded value is not meaningful. Ideally, nonpoint pollutants from the land surface should be analyzed in terms of mass loading rates in order to mask irrelevant concentration variations (1, 12). The simulation results are presented in concentrations because few NPS Model users will have sufficient data to calculate mass loading rates during storm events; hence, comparing simulated and recorded concentrations will be the most common method of calibration.

Although the P2 watershed was simulated for only one summer growing season, the nutrient runoff data appears to corroborate other studies on agricultural runoff discussed in Section 3.0. The NPS Model simulation results indicate sediment is a reasonable indicator for total nutrient loads (e.g. Total P, Total N) from the P2 watershed, but not for individual constituents such as NO_3-N and PO_4-P found in the solution phase of surface runoff.

P6 WATERSHED, EAST LANSING, MICHIGAN

The P6 watershed was also simulated for nutrient loadings during the 1974 growing season. The monthly values shown in Figures 25 and 26, and listed in Table 5, indicate substantial differences between the monthly simulated and recorded runoff, sediment loss, and nutrient values. The discrepancies in the nutrient loadings are a direct result of problems with the hydrologic simulation. The large over-estimate of runoff in May is due to the inability to represent the hydrologic impact of tillage operations. On May 13 and 14, the P6 watershed was plowed to a depth of 25 cm. During the following three days, up to 60 mm of rainfall soaked into the fallow ground with negligible runoff produced. The NPS Model simulated the period as if plowing had not occurred, resulting in high simulated runoff and

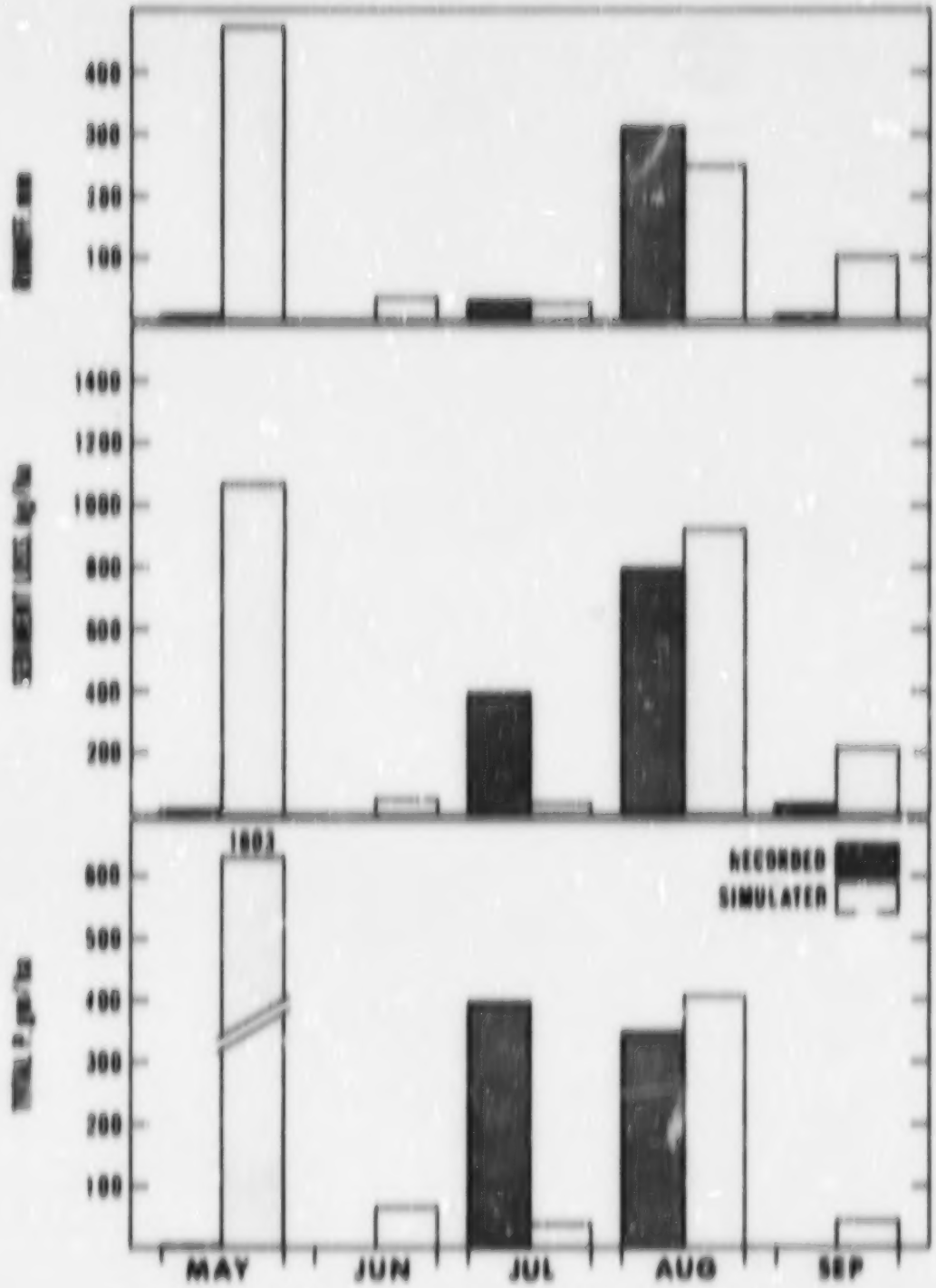

Figure 25. Monthly runoff, sediment and Total P loss from the P6 watershed (May-September 1974).

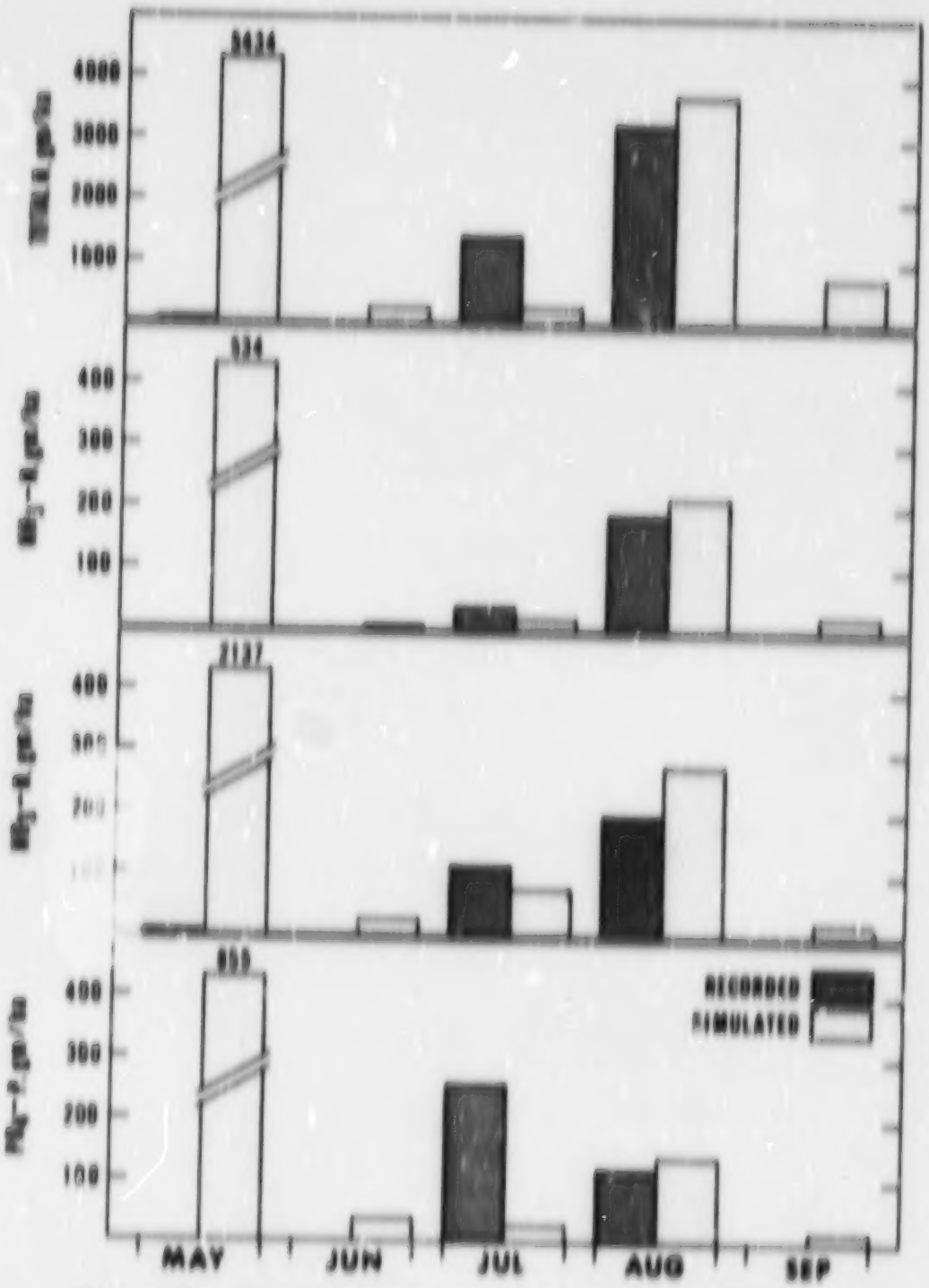

Figure 26. Monthly Total N, NH_3-N, NO_3-N and PO_4-P loss from the P6 watershed (May-September 1974).

TABLE 8. MONTHLY SIMULATION RESULTS AND RECORDED DATA FOR THE P6 WATERSHED (May - September 1974)

Month		Runoff mm	Sediment kg/ha	Total P gm/ha	Total N gm/ha	NH_3-N gm/ha	NO_3-N gm/ha	PO_4-P gm/ha
May	Rec.	3	15.	2.	59.	0	3.	0
	Sim.	472	1069.	1603.	5343.	534.	2137.	855.
June	Rec.	0	0	0	0	0	0	0
	Sim.	36	55.	56.	220.	6.	27.	38.
July	Rec.	30	390.	395.	1401.	34.	112.	256.
	Sim.	27	38.	38.	231.	19.	77.	26.
August	Rec.	310	796.	347.	3218.		196.	117.
	Sim.	249	921.	406.	3683.	418.	277.	138.
September	Rec.	0	35.	0	0	0	0	0
	Sim.	102	211.	43.	737.	21.	21.	17.

sediment loss. Since monthly potency factors were used in this simulation, the over-simulated sediment loss also caused high estimates of nutrient loss in May although fertilizer applications occurred after the major events.

The other discrepancies in Figures 25 and 26 exist because the P6 watershed is too small (0.8 ha) for an accurate simulation with the 15-minute simulation time step used in the NPS Model. This is also true for the P2 watershed although the impact was not as dramatic as on P6. The entire sediment and nutrient losses for P6 in July occurred in one summer thunderstorm (7/02/76) that lasted less than 15 minutes. Although the storm was only moderate (peak flow of 0.04 cms), it was the first significant summer event and occurred with little crop canopy, resulting in high sediment and nutrient losses. Because of its short duration, the storm could not be accurately represented by the NPS Model. Except for this July storm, the only other significant storm events during the 1974 growing season occurred in August. Fortunately, these events were of sufficient duration for a reasonable simulation. Figures 27 and 29 show the runoff, sediment, and total P concentration, and Figures 28 and 30 provide the Total N, NH_3-N, NO_3-N, and PO_4-P concentrations for each event. The problems with the hydrologic simulation are evident. For the August 13 storm (Figure 27), the two recorded flow peaks are simulated as a single peak; the first flow peak, which occurs within seven minutes from

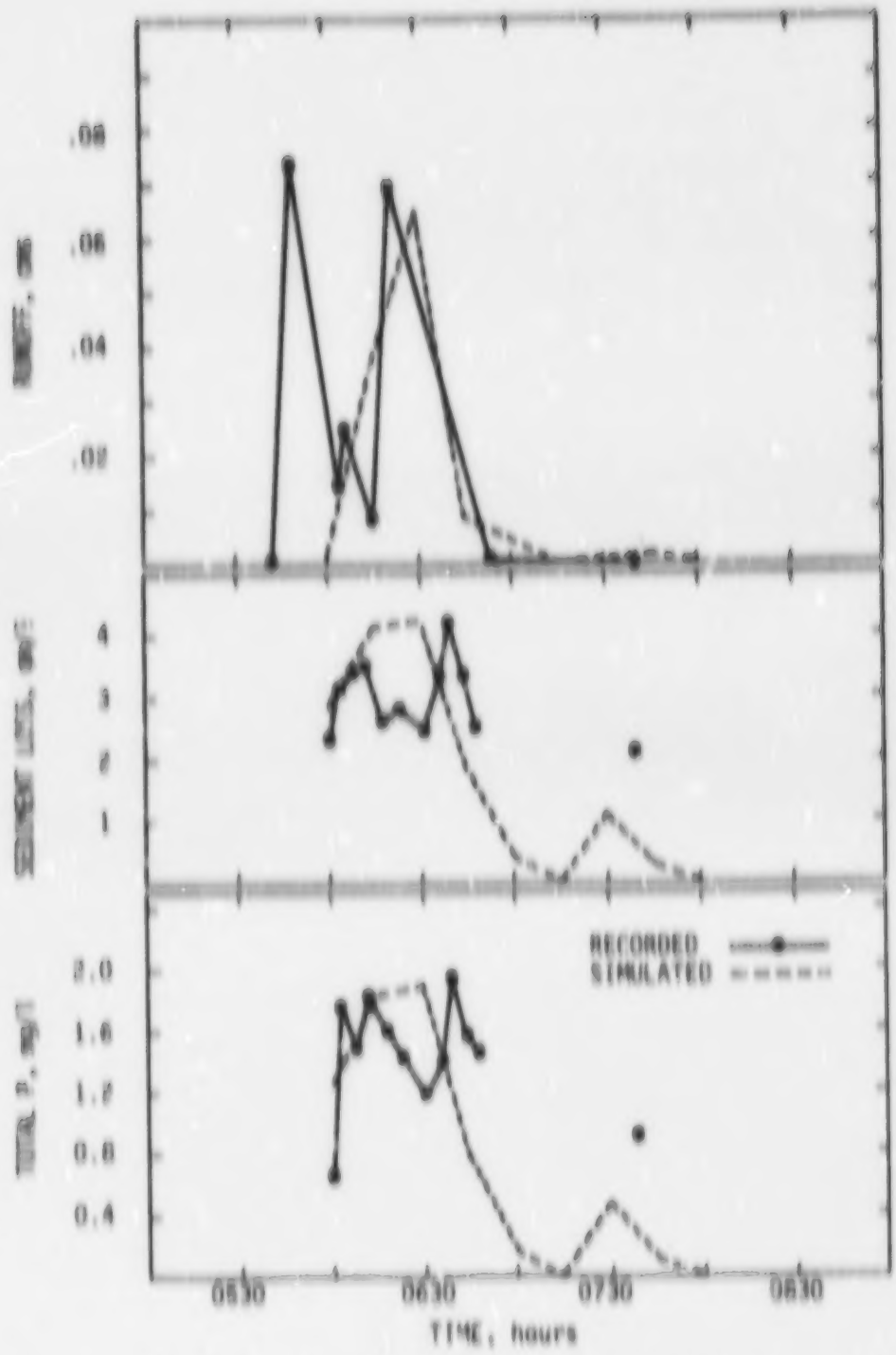

Figure 27. Runoff, sediment loss and total P concentration for the P6 watershed for the storm of August 13, 1974.

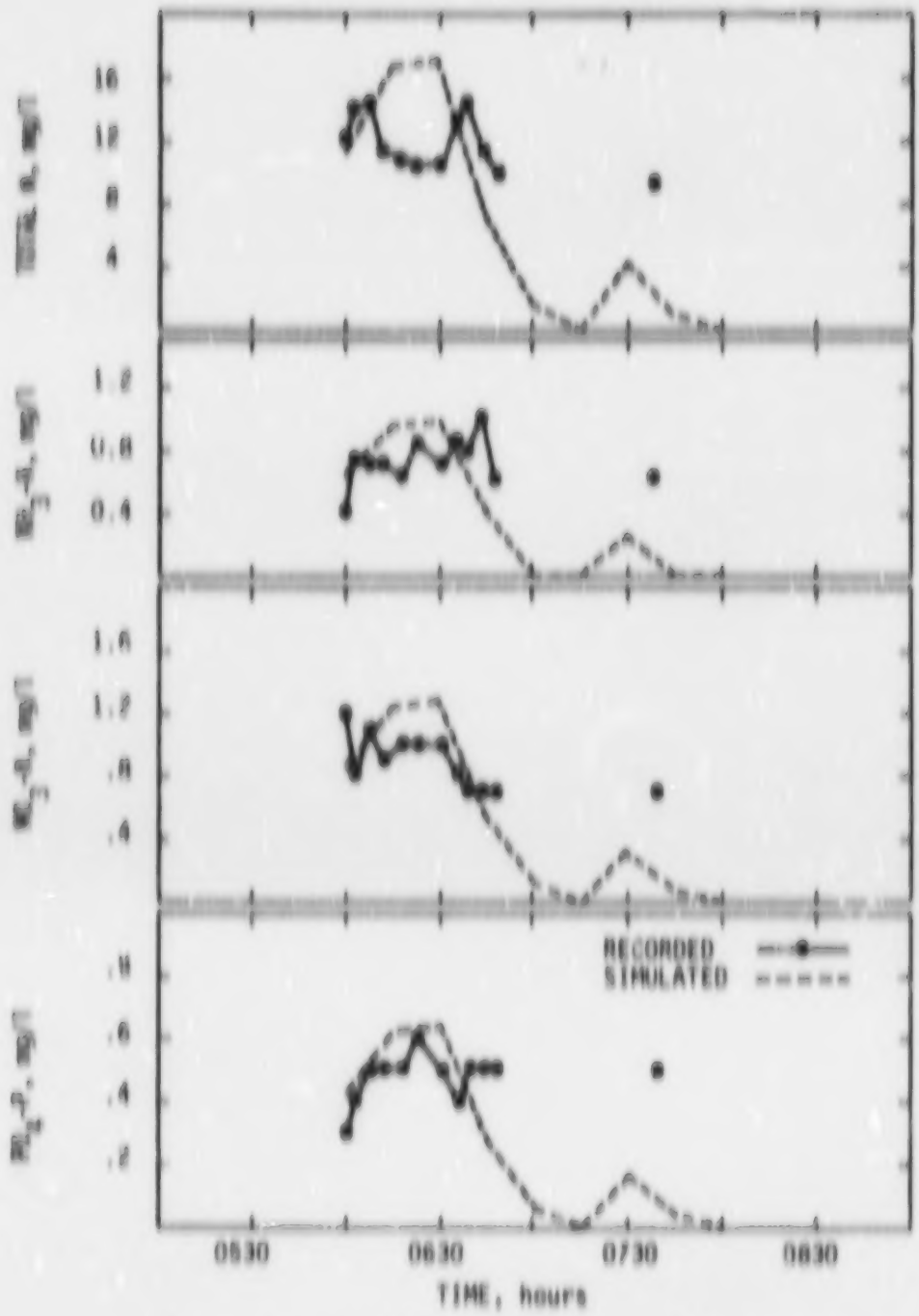

Figure 28. Total N, NH_3-N, NO_3-N and PO_4-P concentrations for the P6 watershed for the storm of August 13, 1974.

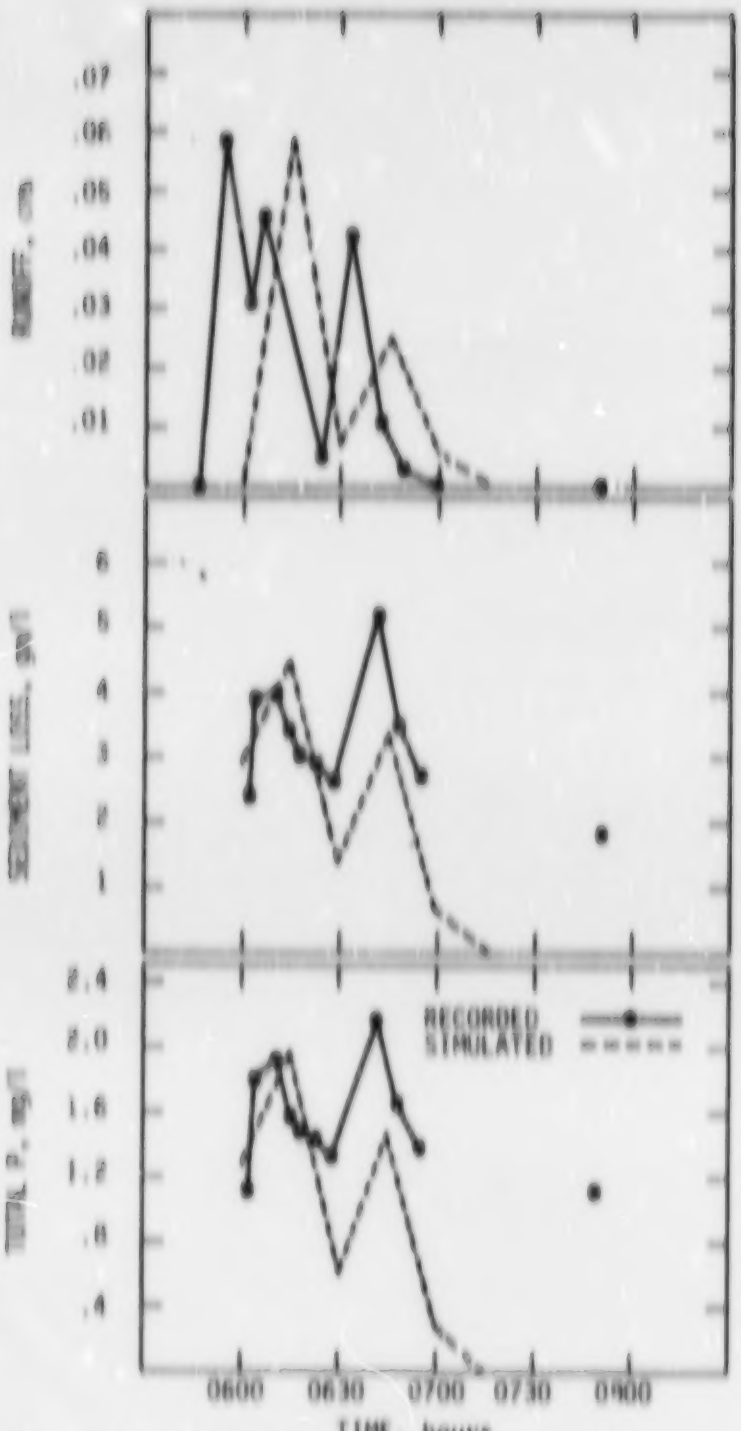

Figure 29. Runoff, sediment loss and total P concentrations for the P6 watershed for the storm of August 27, 1974.

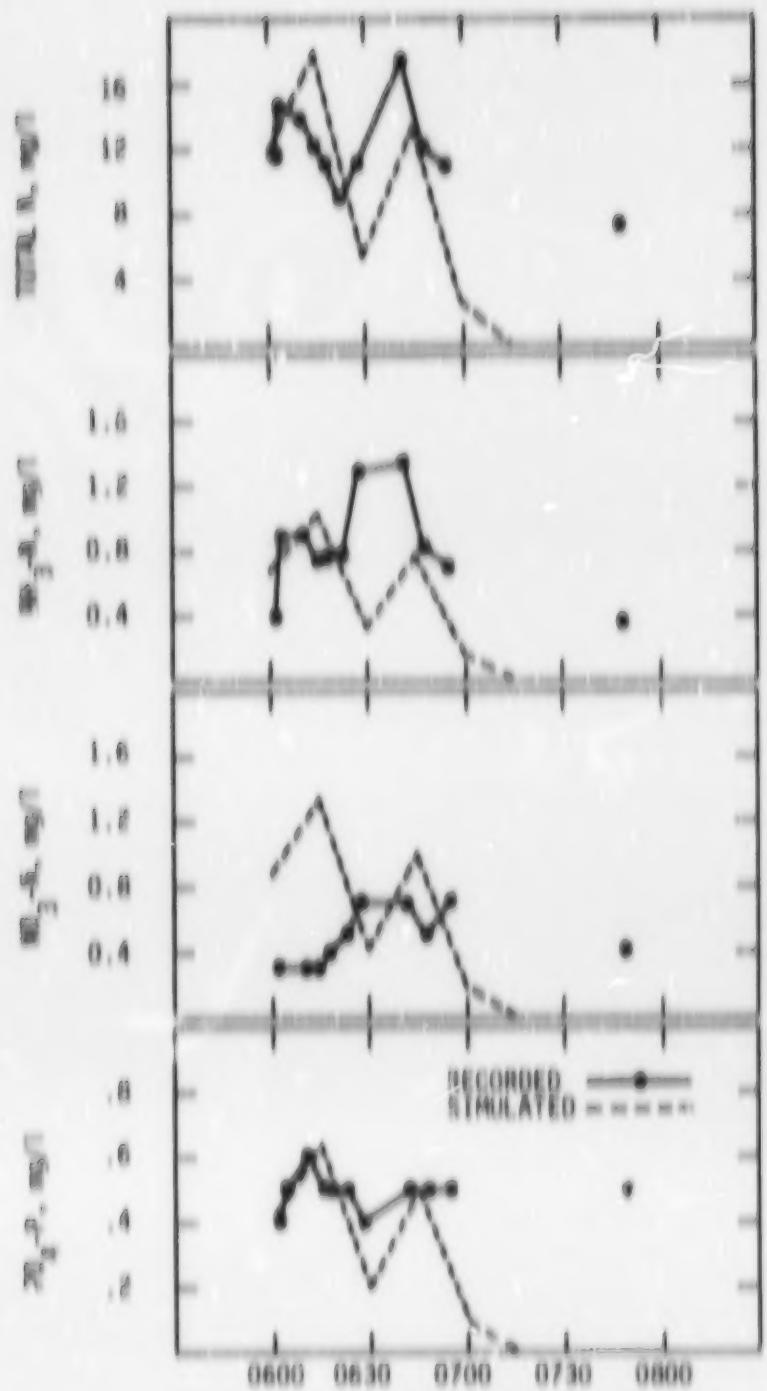

Figure 30. Total N, NH_3-N, NO_3-N and PO_4-P concentrations for the P6 watershed for the storm of August 27, 1974.

the beginning of the storm, is not represented. For the August 27 storm, the three recorded flow peaks are simulated as two. Since only one precipitation gage recorded rainfall for P6, the discrepancies between the simulated and recorded runoff are likely due to both the gross simulation interval and the areal variability in rainfall prevalent for thunderstorms in the region.

Despite these discrepancies, the runoff simulation for the August storm events is adequate for evaluating the sediment and nutrient simulation results. The conclusions stated for the P2 watershed apply also to the P6 watershed. The double-peak behavior of the recorded sediment for both storm events is reflected by the Total P and Total N concentrations. The NH_4-N, NO_3-N, and PO_4-P concentrations do not follow this pattern, except for the NH_4-N values on August 27 (Figure 32). The concentration variation in that storm would appear to indicate sediment is a significant transport medium for NH_4-N. As on the P2 watershed, high concentrations occurring at minor runoff rates at the end of the storm event are considered unreliable and are not connected to the other data points.

The simulated sediment and nutrient concentrations were adjusted by calibration of the potency factors. Since both storms occurred in August, the same potency factor was utilized verifying the use of average monthly values. Considering the discrepancies in the runoff simulation, the agreement between the simulated and recorded sediment, Total P, and Total N values is reasonable. Improving the runoff and sediment simulation would obviously improve the Total P and Total N simulation results. The same is true for NH_4-N for the August 27 storm, but the results are inconclusive for the August 13 storm. As for the P2 watershed, the NO_3-N and PO_4-P were measured only in solution; thus sediment is not a reliable indicator for these constituents. The agreement between the simulated and recorded PO_4-P concentrations is likely coincidental, especially for the August 13 storm where the sediment variations are not well represented.

In general, simulation of the P6 watershed has dramatized considerations important in calibrating the NPS Model to agricultural watersheds. The watershed should be large enough to allow a 15-minute simulation interval. Intense thunderstorms that begin and end in less than two or three intervals may not be adequately simulated. The hydrologic impact of tillage operations is not represented in the NPS Model; this topic is an area of continuing research. The monthly potency factors apply to all events in the same month; thus, events that precede and follow fertilizer applications may need to be calibrated separately. Because the day of planting and fertilizing will vary from year to year, the use of monthly potency factors should be sufficient for estimating average monthly nutrient loadings. The user needs to be aware of these considerations when calibrating the NPS Model.

Although differences exist between the simulated and recorded monthly values for P6, the storm simulation results indicate total nutrient loads can be reasonably simulated with the NPS Model using sediment as an indicator. These results confirm the findings from the P2 simulation.

SUMMARY

The NPS Model can be used to estimate total nutrient loadings from the land surface of urban and agricultural areas. Test results on a 433-ha urban watershed (Third Fork Creek) in Durham N.C. show that simulated Total P and Fe concentrations during a storm compare well with recorded values. Total annual loadings for 1977 were within 20% of the values estimated from regression analysis of the data. Simulated TKN concentrations and loadings were less accurate due to TKN concentrations in baseflow. Since in-stream processes and subsurface pollutant contributions occur in Third Fork Creek and are not simulated in the NPS Model, the size of the watershed approaches the upper limit of applicability of the model.

Where subsurface contributions are significant, the NPS Model should be modified to allow specification of average monthly pollutant concentrations in subsurface flow. If in-stream processes are major, the NPS Model should be interfaced with a stream water quality model. Both of these procedures would be required to simulate nonpoint pollution in large watersheds.

Nutrient concentrations and loadings were also simulated from two small agricultural watersheds (1.3 and 0.8 hectares) in Watkinsville, Georgia and East Lansing, Michigan for the 1974 growing season. Total P and Total N concentrations and loading were adequately simulated because these nutrient forms are largely associated with the sediment fraction of surface runoff. NH_4-N values were not simulated as well as Total P and Total N since NH_4-N transport in solution was found to be significant. NO_3-N and PO_4-P values were not adequately represented because they are transported almost entirely in solution form. Accordingly, the NPS Model should not be used to estimate loadings for these nutrient forms.

Just as Third Fork Creek approaches the upper size limit for the NPS Model, the agricultural watersheds were too small for accurate representation of the hydrologic and sediment characteristics. The NPS Model should only be applied to watersheds for which the 15-minute simulation interval is reasonable. The range of watershed sizes simulated in this study (0.8 to 433 hectares) provides estimates of the upper and lower bounds of applicability.

The nutrient simulation results were obtained by estimating the nutrient potency factors (i.e. nutrient loss/sediment loss x 100%) from observed data and then calibrating the values by comparing simulated and recorded concentrations. The goal was to evaluate the use of sediment loss, as simulated in the NPS Model, as an indicator of nutrient loadings in surface runoff. Further testing and verification should be conducted to see if the potency factors can be estimated, without calibration, as a function of fertilizer applications, management practices, soil characteristics, crop behavior, etc. Only in this way can the NPS Model be effectively applied in areas where little data is available.

The conclusions presented in this report do not mean that soluble nutrient forms are unimportant. In areas where subsurface flow is a major portion of total runoff, soluble nutrient forms may comprise much of the nutrient loading. The literature and results of this work indicate that total nutrient loads in surface runoff are associated largely with sediment. Until research can accurately represent the complex reactions and transformations of nutrient forms in all flow components, the NPS Model can be used to estimate total nutrient loads in surface runoff as a function of sediment loss.

SECTION 5.0

ESTIMATION OF NUTRIENT POTENCY FACTORS

Section 4.0 noted the nutrient potency factors for the test watersheds were initially derived from the observed data and adjusted by calibration. This is the most reliable means of determining potency factors for use with the NPS Model. The factors for the three test watersheds are presented in Table 6; except for the Third Fork Creek values, they compare well with factors developed from the literature (Table 7). Third Fork Creek had unusually high sediment loss for an urban watershed, resulting in low potency factors.

Considerable variation exists in the values shown in Table 7. Nutrient potency factors are dependent upon soil characteristics, land use, climate, hydrologic behavior, etc. Obviously fertilizer applications on agricultural watersheds, lawns, and golf courses have a significant impact. It is difficult to accurately predict nutrient potency factors without calibration or observed data for the specific watershed. When applying the NPS Model, data on the watershed or on nearby watersheds with similar soils, land use, topography, etc. should be used to evaluate the potency factors and the resulting simulated nutrient loadings. If no such data is available, Tables 6 and 7 can provide a range of possible values from which the potency factors can be estimated. However, simulated nutrient loadings derived from such potency factors should be considered only as gross estimates until data for calibration is available. In Table 7, the greatest confidence can be assigned to the Total P, Total N, and TKN potency factors obtained from continuous data collection programs. The remaining constituents are not as closely associated with the sediment fraction of surface runoff; they are included for general information only. Grab sample data collection programs cannot accurately represent the variability of nonpoint pollutants in surface runoff. Table 7 is only a sample of the data available on nutrient runoff. The user should consult the references in Table 7 for a detailed description of the data collected, and should investigate the general literature for additional sources.

TABLE 6. NUTRIENT POTENCY FACTORS FOR THE TEST WATERSHEDS

Watershed	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Third Fork Creek[a], Durham, N.C.												
TKN	.090	.055	.060	.060	.055	.055	.055	.055	.060	.060	.067	.070
Total P	.080	.065	.070	.070	.070	.050	.060	.060	.065	.060	.070	.075
Fe	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3
P2 Watershed Watkinsville, Ga.												
Total N					0.22	0.40	0.45	0.38				
Total P					0.15	0.13	0.06	0.06				
NH_3-N					0.05	0.12	0.08	0.30				
NO_3-N					0.06	0.05	0.015	0.08				
PO_4-P					.002	.007	.005	.005				
P6 Watershed East Lansing, Mi.												
Total N					.500	.400	.600	.420	.356			
Total P					.150	.120	.100	.044	.020			
NH_3-N					.050	.010	.050	.023	.010			
NO_3-N					.200	.050	.200	.030	.010			
PO_4-P					.080	.070	.066	.015	.006			

a Third Fork Creek had unusually high sediment loss for an urban watershed, resulting in low potency factors.

TABLE 7. NUTRIENT POTENCY FACTORS FOR URBAN AND AGRICULTURAL WATERSHEDS DERIVED FROM THE LITERATURE[a]

Location	Name	Size (ha)	Land Use	Soils	Geographic Region	Potency Factors						Ref.
Urban												
Lubbock, TX	Elm Cr. Storm Sewer	407	Residential & commercial		Texas/Plains					.021	.729	15
Lubbock, TX	49 Drop Basin	16	Residential		Texas/Plains					.364	.031	15
Lawrence, KS	Research Drive	24	Residential	Silty loam, silty clay	Prairie					.27 min .32 max		17
Tulsa, OK	Lime Basin	777	Residential, com. commercial	Claystone & shale geology	Prairie		.22[b]				.300	18
Tulsa, OK	Mee Knock Basin	150	Residential	Claystone & shale geology	Prairie		.32[b]				.480	18
Tulsa, OK	Joshua Basin	65	Streets, com-mercial & residential	Claystone & shale geology	Prairie		.40[b]				.405	18
22 U.S. Cities			Residential Industrial Commercial		Cont/Mixed, Cont/Mixed, Cont/Mixed		.230 .083 .157			.086 .057 .068	.110 .142 .222	19
Madison, AL	Monte Sano Storm Basin	40	Residential		Cont/Prairie	2.39	2.12	.4[c]	.196	.276	.211[d]	7
Seattle, WA	Thornton Cr. & Tr.	207	Single & mul-tiple family residential		Prairie	2.24	2.31	.230[b]	.261	.470	.380	20
Seattle, WA	Lake Hills	60	Single family residential		Prairie	2.22	1.75	.237[b]	.222	.562	.233	20
Seattle, WA	Highlands	39	Low density, single family residential		Prairie	1.13	.77	.290[b]	.240	.370	.240	20
Seattle, WA	Taxiformer	32	Commercial, new shopping area		Prairie	2.54	1.83	.280[b]	.230	.666	.240	20
Seattle, WA	Central Services Dist.	31	Commercial downtown		Prairie	1.62	.74	.280[b]	.261	.234	.159	20
Seattle, WA	South Seattle	31	Industrial		Prairie	2.33	1.63	.237[b]	.252	.435	.265	20
Agricultural												
Christian, IN	C-1, C-2, C-4	7 to 28	Cotton[e]	Silty & with clay	Cont/Prairie	.19	.34	.146	.095	.042	.022[f]	21
Christian, IN	C-5, C-6, C-9	5 to 11	Wheat[e]	Silty & with clay	Cont/Prairie	.22	.25	.138	.034	.067	.027[f]	21
Christian, IN	C-7, C-8	6 to 11	Pasture	Silty	Cont/Prairie	.05	.09	.027	.002	.009	.001[f]	21
Tangier, VA		32	Corn[e]	Fine silty loam	Cont/Prairie	.23	.37	.063	.002	.031	.007[f]	14

TABLE 2. [illegible]

Location	Name	Type Soil	Land Use	Soils	Satellite Region	Parameter Numbers						

Notes:

a. These values are overall averages for all crops events and were obtained from subsequent data or annual readings. These values are provided as general information. the user should refer to the cited references for greater detail.

b. Organic Nitrogen only

c. Dissolved Reactive Phosphorus

d. Dilute acid hydrolyzable Phosphorus

e. Insufficient was applied

f. Total Soluble Phosphorus

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APPENDIX A

MODIFICATIONS TO THE NPS MODEL

Modifications to the NPS Model performed during this study were kept to a minimum so as not to require major changes in the input sequence described in the original report. Only changes required to better represent physical processes and maintain consistency of units were included. The modifications are as follows:

(1) The units of SRERI and TSI, the initial sediment deposits on pervious and impervious areas, were changed from kg/ha (lb/ac) to tonne/ha (tons/ac) in order to coincide with the units of "accumulated sediments" output before each storm event and in the monthly summary.

(2) EPXM, the interception storage parameter, was changed from a single average annual value to 12 monthly values corresponding to the first day of each month. The interception storage on any day is calculated from linear interpolation between the monthly values. This modification was included to better represent changes in rainfall interception with crop growth on agricultural watersheds. Although EPXM is not usually a critical parameter, it can be important on extremely small watersheds highly responsive to rainfall. To accommodate this change, the input namelist, LND3, has been modified to accept 12 values for EPXM. So, LND3 may appear as

```
ALND3  KI=1.0, PETMUL=1.0, K3=0.30, EPXM=5*0.0,.01,.03,.06,
       .10,.1,2*0.0, K24L=1.0, KK24=0.0                    &END
```

If less than 12 values are input for EPXM, the remaining ones are defaulted to 0.0 mm (in).

(3) A major impact of tillage operations is to increase the amount of fine sediment material available for transport. In an attempt to accommodate this effect, the NPS Model was modified to accept the dates of tillage operations and a new value of the sediment fines storage resulting from the operation.

Two new input parameters, TIMTIL and SRERTL have been added to the WSCH namelist. TIMTIL specifies the Julian day of the operation while SRERTL indicates the corresponding new value of the sediment fines storage. Up to 12 values can be specified for each parameter, i.e. up to 12 separate tillage operations can be specified. Whenever the day of simulation corresponds to a value in TIMTIL, the fines storage is

reset to the corresponding SRERTL value. Thus, the 1st value of TIMTIL is the day when the fines storage is reset to the 1st value of SRERTL, the 2nd TIMTIL value corresponds to the 2nd value of SRERTL, etc.

The input namelist, WSCH, would appear as follows for only one tillage operation.

```
 &WSCH ARFRAC=1.00, IMPEQ=0.0, COVVEC=5*0.0,.05,.2,.75,.85,
       .80,2*0.0, TIMTIL=142, SRERTL=0.5                    &END
```

When day number 142 is simulated the following message is printed on the first simulation interval of day number 142:

```
*** May 22 - LAND SURFACE DISTURBANCE OCCURS ON CROPLAND
             SEDIMENT DEPOSITS ON PERVIOUS AREAS RESET
             TO 0.500 TONS/ACRE
```

Therefore, the operation is assumed to occur at the beginning of the day. TIMTIL and SRERTL do not have to be specified if tillage is not considered in a particular land use.

This procedure was developed and initially tested on small agricultural watersheds in Georgia (12). Although this does not account for all the complex impacts resulting from tillage operations, it appears to be the only method available for continuous simulation of erosion processes. Calibrated values of SRERTL range from 1.0 to 4.5 tonnes/hectare (0.5 to 2.0 tons/ac) on the limited number of watersheds tested. SRERTL is a function of soil properties, depth, and type of tillage operations, but at the present time must be determined by calibration. The effect of construction activity could also be approximated with this method although no testing on construction areas has been performed.

The user should refer to the NPS Model report for a full description of the parameters, the input formats, and the calibration process of applying the NPS Model.

APPENDIX B

CORRECTION AND ADJUSTMENTS TO THE NPS MODEL INPUT DESCRIPTION

Table B is an updated version of Table 36 from the NPS Model Report (1) which described the input sequences and attributes of the model parameters. Errors in the original Table 36 are noted by slashes (/) in Table B with the corrections inserted. Modifications performed during this study are included in the NPS Model version dated 11/15/76 and are noted by asterisks (*) in Table B.

Also, Table 24 of the NPS Model Report incorrectly indicates that daily potential evapotranspiration (PET) is input in English units of "inches x 100"; this should be corrected to "inches x 1000".

TABLE B. ADJUSTMENTS TO TABLE 36 OF THE NPS MODEL REPORT: NPS MODEL PARAMETER INPUT SEQUENCE AND ATTRIBUTES

Mnemonic Name	Parameter Name	Type	English Units	Metric Units	Comment
	Watershed Name	character			up to [illegible] characters
	Computer Run Information	character			up to [illegible] characters
RUN1	IYEAL	integer			[illegible]
	IYHigh	real	ft /sec	m /sec	[illegible]
	NLAND	integer			up to 5 land uses
	NQUAL	integer			up to 5 pollutants
	SNOW	integer			0 or 1
	[illegible]				[illegible]
OTYP	WRIT	integer			[illegible] or 1
	PLOT	integer			0 or 1
	NOVAR	integer			0 or 1
STRT	BGNDAY	integer			
	BGNMON	integer			
	BGNYR	integer			
ENDT	ENDDAY	integer			
	ENDMON	integer			
	ENDYR	integer			
LND1	UZSI	real	inches	millimeters	
	LZSI	real	inches	millimeters	
	INFIL	real	in/hr	mm/hr	
	INTER	real			
	IRC	real			
	AREA	real	acres	hectares	
LND2	NN	real			
	L	real	feet	meters	
	SS	real			
	LI01	real			
	LI	real	feet	meters	
	SSI	real			
LND3	KI	real			
	PETMAX	real			
	K3	real			
	DEPSI	real	inches	millimeters	(12 MONTHLY VALUES)*
	KDAL	real			
	KKDA	real			

* Added to NPS Model version dated 11/15/76

TABLE 8. (continued)

Namelist item	Parameter item	Type	English units	Metric units	Comment
LNDU	UES	real	inches	millimeters	
	LZS	real	inches	millimeters	
	SQU	real	inches	millimeters	
SNOI	RADCON	real			
	ECFAC	real			
	EVAPSN	real			
SNOE	IELEV	real	ft.)	meters	
	ELDIF	real	(XXX feet	kilometers	
	TSNOW	real	degrees F	degrees C	
SNOW	LPACK	real	inches	millimeters	
	RMPI	real	in/day	mm/day	
	WE	real			
	TSNS	real			
SNOW	DEF	real			
	WPAN	real			
	RPAN	real			
	F	real			
	KUSI	integer			
SNOS	PACK	real	inches	millimeters	
	DEPTH	real	inches	millimeters	
WASH	JUER	real			
	KMER	real			
	JSER	real			
	KSER	real			
	JETI	real			
	KETI	real			
	TCF	real			12 values
	Pollutant name	character			up to 8 characters [a] repeat for each pollutant
REPEAT THE FOLLOWING INFORMATION FOR EACH LAND USE					
	Land Use Type	character			up to 12 characters
WSEI	AREAC	real			
	IMPED	real			
	CUVVEC	real			12 values
	TIMIC	real			(12 VALUES OPTIONAL) [b]
	SOLAIL	real	ton/ac	tonne/ha	(12 VALUES OPTIONAL) [b]

[a] Each pollutant name is followed by the concentration units to be used, either 'MG/L' or 'UM/L', beginning in column no. 15 (see Appendix D). 'UM/L' is the default value.

[b] Added to HPS Model version dated 11/15/76

TABLE 8. (continued)

Namelist Name	Parameter Name	Type	English Units	Metric Units	Comment
VPTH	PIPVEC PHIVEC	real real	percent percent	percent percent	1 value per pollutant include if IDIVAR=0
IPTH	PIPVAT PHIVAT	real real	percent percent	percent percent	12 values per pollutant include if IDIVAR=1
VACR	ACUP ACUI	real real	lb/ac/day lb/ac/day	kg/ha/day kg/ha/day	1 value per pollutant include if IDIVAR=0
IACR	ACUPV ACUIV	real real	lb/ac/day lb/ac/day	kg/ha/day kg/ha/day	12 values per pollutant include if IDIVAR=1
VRIR	REPER RETIP	real real	day day	day day	1 value per pollutant include if PIVAR=0
IRIR	REPERV RETIPV	real real	day day	day day	12 values per pollutant include if IDIVAR=1
IUAE	DREMI TST	real real	lb/ac lb/ac	kg/ha kg/ha	(UNITS CHANGED IN * kg/ha/st tonne/ha)

* Added to NPS Model version dated 11/15/76

APPENDIX C

NPS MODEL SOURCE LISTING

```
//[illegible] JOB ([illegible],5,5,5),'[illegible]',[illegible]
/*JOBPARM [illegible]
//[illegible] EXEC FORTCL,PARM.FORT='[illegible]'
//FORT.SYSIN DD *
C
C
C
C     ****************************************************************
C     *                                                              *
C     *          NONPOINT SOURCE POLLUTANT LOADING (NPS) MODEL       *
C     *                                                              *
C     ****************************************************************
C
C                         VERSION DATED  NOV. 15, 1976
C
C                            DEVELOPED BY:  HYDROCOMP, INCORPORATED
C                                           1502 PAGE MILL ROAD
C                                           PALO ALTO, CA.  94304
C                                             415-493-5020
C
C                                       FOR:  U.S. ENVIRONMENTAL
C                                             PROTECTION AGENCY
C                                             OFFICE OF RESEARCH
C                                             AND DEVELOPMENT
C                                             ENVIRONMENTAL
C                                             RESEARCH LABORATORY
C                                             ATHENS, GA.  30601
C                                               404-546-3581
C
C
C                                NPS - MAIN PROGRAM
C
      IMPLICIT  REAL(A)
C
      DIMENSION RNAME(20),SAQI(20),TEMPS(120),WINDS(120),SATURS(120),
     1          IRAIN(366),IBASIN(5),IVI(20),IVA(20),IGROUP(20),
     2          ISTAB(12,5),ZI(20),SRAD(120),SALDIS(120),WIND(120),
     3          ARTOUT(20),ARSOUT(20),CONVRC(12),DEPDEN(5,12),TUC(12),
     4          TOTALS(20,6),RUNOFF(20),TRANS(20),QUALS(20),AVBASE(20),
     5          POLNUM(5,12),ADSURF(5,12),..SDYARD(5,5,12),PRAYARD(5,5,12),
     6          ACCPNT(6,10)
C
      COMMON /ALL/ DU,HTRIB,UTCAL,DEPZ,UBAT,TAPING,ASC,AREA,BASE,DTIME,
     1          RNAME,SOSU,SRUN,IMPP,BOD,BODC,UASE,PBASE,BIO,DT,DD,
     2          RUPLA,LAST,PRAT,TRAPE,IDS,IHOD,PE,QOUT,A,DS,CONF,BOD1,
     3          DEPR(5),TWIT,LBOUND(5),SI,AP(7),QUALIN(5),QC,WIDI,BOD,
     4          NO,A,OPL,UTAP,UNITIN,DI,UNITIS,DI,UNITIS,DI,WIDI,
     5          NUT,DEPR,ROUGH,PERMI,PERMI,ARUS,LAYS,DI,IMPA(20),
     6          BLAGD,NOCAL,SYACH,IDO,IOI,BICOUT(5),PLOWE,SCALEP(5),
     7          SNOW,DACR,IPACR
C
      COMMON /LARR/ DAY,DATA,IRIN,IR,TRANS,SOIL,GWS,ET,LIBUS,LAND,AATA(9),
     1          U2,IE,UEEN,LOOK,IMPIL,IAYER,SOW,DPC,DRC,IJ(20),
     2          KZ(6),DAIS,CAPEL,BC,IPR,R3,DTANI,RANG,RRRR,SCRF,IBC,
     3          SNOP(6),RAPIN,FOOPA,ARTOPT,CCFAC,SCRF,IRRIG,DAIE,IBC,
     4          SCP,IDOC,P,DSN,SC,RPACK,RVAPOR,ALLET,FOSOW,PPVAIR,
     5          DSWE,DEPTH,MONTH,THIN,PIVRAT,IAGIT,DOSE,WIND,IRRIGW,
     6          TRNOAL,RCRTOR,ROOTOT,ITO,SOILOR,SOILWOT,ORAD,CORIOL(9),
     7          INPTOT,RDAR,RAD,RRCI,POAR(12)
```

```
      C
            COMMON /COL0/ [illegible]
           1              [illegible]
           2              [illegible]
           3              [illegible]
           4              [illegible]
           5              [illegible]
           6              [illegible]
      C
            COMMON /LABOUR/ [illegible]
           1                [illegible]
           2                [illegible]
           3                [illegible]
           4                [illegible]
           5                [illegible]
           6                [illegible]
      C
            COMMON /LAND/ [illegible]
           1              [illegible]
           2              [illegible]
           3              [illegible]
           4              [illegible]
           5              [illegible]
           6              [illegible]
      C
            EQUIVALENCE (BOSTON,ABIDUT(1)),(YEARSOL,ABIDUT(1))
      C
            LOGICAL LAST, PREV
      C
            INTEGER  BURDAY, CONSCH, DUETS, ENJOAT, ERUPCH, EPOCH,
           1         EPIGRT, EVIDO, YEAR, DAY, H, LOCAL, VIAE, PIAV, IRRIPO,
           2         TJ, CR, TT, DA, DY, UNIV, SHOW, LAVA, RECOUT, REFAC,
           3         VIAVIC, VILOAV, DPA
      C
            REAL  IRC, RR, VSI, DV, R/SL, EACH, IRFIR, IRTER,
           1      IPA, ICE, RIAEL, AI, ABETTOR, ABBYOT, IDEA, ORGACH,
           2      JOYA, ZOOM, JOBB, ERUP, EARIN, DATA, AILOV, BOOT,
           3      AI, DAY, IRCH, BEAIAN, ABELRAY, IPACH, IRPRO,
           4      ABETTOR, IRTYOT, IVER, RAPIN, YOUOPY,
           5      ZOOPLY,ROOPHA
      C
            REAL*8  BOYARE,PTYPE,UTYPE
      C
      C                 HANDLING INPUT VARIABLES
      C
            HANDLIST /PUPT/  HYCAL, DYAIN, OLAND, OLVAL, OBOB
            HANDLIST /IIPP/  U.OUT, PIRT, ADYAR
            HANDLIST /IPOUT/ BUOUT, BOBBIN, BUYER
            HANDLIST /INOD/  BOOCAT, EUDRUN, IN.OTE
            HANDLIST /LOUT/  UIOR, LOOP, IOPPL, IMPER ,IRC, ADEA
            HANDLIST /LOUT/  RR, L, RR, RRI, LI, OSI
            HANDLIST /LOUT/  AT, DAYOUL, AI ,OPEN, R/SL, BEEN
            /HANDLIST /LOUT/ UCA, LEA, ALE
            HANDLIST /OUT/   AABOOR, IUPAC, OYAPER
            HANDLIST /OUT/   OELOY, PLOIP, PUBOB
            HANDLIST /OUT/   APACH, IOR, DU, IRRE
            HANDLIST /OUT/   OCP, BAUL, ARUL, P, AUGI
            HANDLIST /OUT/   PALE, OPPTU
            HANDLIST /OUT/   ADPPAC ,IAOBO, UUYOC, FIRYIL, OBBBYL
            HANDLIST /OUTP/  PUPYOC, PRIYOC
```

```
C
C          NAMELIST /PRTR/  PRDMAT,PRIRAT
C          NAMELIST /WATR/  /RRR, RRRR, JRRR ,RRRR, JRIR, RRIR, RCP
C          NAMELIST /TRCR/  ACUP,ACUI
C          NAMELIST /PACR/  ACUPP,ACUIP
C          NAMELIST /TERR/  RFPR, RRIRP
C          NAMELIST /TMPR/  RRPRPP,RRIRPP
C          NAMELIST /IRRG/  RRRRR, PRI
C
C
C               NAMELIST INPUT PARAMETER DESCRIPTION
C     NVCAL  I  INDICATES TYPE OF CIRCULATION RUN
C               =  1  HYDROLOGIC CALIBRATION
C               =  2  NUTRIENTS AND QUALITY CALIBRATION
C               =  3  PRODUCTION RUN (PRINTER OUTPUT)
C               =  4  PRODUCTION RUN (PRINTER & W/T DIAGNOSTIC OUTPUT ON UNIT 9)
C     NTRIN  I  MINIMUM FLOW FOR OUTPUT DURING A TIME INTERVAL (CFS, CMS)
C     UNTS   I  ENGLISH(1-5), METRIC(2)
C     NLAND  I  NUMBER OF LAND TYPE USED IN THE WATERSHED
C     NQUAL  I  NUMBER OF QUALITY CONSTITUENTS SIMULATED
C     NSUB   I  IF 1 DOWNSIZE FOR PRIPUNCH, IF 0 ORIGINAL CALCTS PERFORMED
C     NSVSR  I  MONTHLY VARIATION IN ACCUMULATION RATES, REMOVAL RATES,
C               AND POTENCY FACTORS USED (1), OR NOT USED (0)
C     DINT   I  INPUT PRECIPITATION IN INTERVALS OF 15 MIN.(1), OR HOURLY (0)
C     RUNDAY, RUNMON, RUNYR : DATE SIMULATION BEGINS
C     RUNDAY, ENDMON, ENDYR : DATE SIMULATION ENDS
C     UMAX   I  NOMINAL UPPER ZONE STORAGE (IN, MM)
C     LSUR   I  NOMINAL LOWER ZONE STORAGE (IN, MM)
C     INFIL  I  INFILTRATION RATE (IN/HR, MM/HR)
C     INTOP  I  INTERFLOW PARAMETER, ALTERS RUNOFF TIMING
C     IRC    I  INTERFLOW RECESSION RATE
C     AREA   I  WATERSHED AREA IN ACRES
C     RN     I  MANNING'S N FOR OVERLAND PERVIOUS FLOW
C     RNI    I  MANNING'S N FOR OVERLAND IMPERVIOUS FLOW
C     L      I  LENGTH OF OVERLAND PERVIOUS FLOW TO CHANNEL (FT, M)
C     LI     I  LENGTH OF OVERLAND IMPERVIOUS FLOW TO CHANNEL (FT, M)
C     SS     I  AVERAGE OVERLAND PERVIOUS FLOW SLOPE
C     SSI    I  AVERAGE OVERLAND IMPERVIOUS FLOW SLOPE
C     RI     I  RATIO OF SPATIAL AVERAGE RAINFALL TO GAGE RAINFALL
C     KV     I  INPUT TO ACTUAL EVAPORATION
C     PETMAL I  POTENTIAL EVAPOTRANSPIRATION MULTIPLICATION FACTOR
C     UZRR   I  INFILTRATION STORAGE, IF BLANK OR ZERO VALUE (IN, MM)
C     RIRAT  I  FRACTION OF GROUNDWATER RECHARGE PERCOLATING TO DEEP
C               GROUNDWATER
C     RRZR   I  GROUNDWATER RECESSION RATE
C     UZS    I  INITIAL UPPER ZONE STORAGE (IN, MM)
C     LZS    I  INITIAL LOWER ZONE STORAGE (IN, MM)
C     GWS    I  INITIAL GROUNDWATER STORAGE (IN, MM)
C     RADCOR I  CORRECTION FACTOR FOR RADIATION
C     ECPAC  I  CORRECTION FACTOR FOR CONDENSATION AND CONVECTION
C     RCP    I  RAIN CONVECTION FACTOR FOR SEASONAL CATCH DEFICIENCY
C     ELMSP  I  ELEVATION DIFFERENCE FROM TEMP. STATION TO MEAN BASIN ELEVA
C               (FEET, M)
C     TFMS   I  DENSITY OF NEW SNOW AT 0 DEGREES F,
C     F      I  FRACTION OF GROUNDMT WITH COMPLETE FOREST COVER
C     RDR    I  WATER HOLDING CAPACITY (IN/UNIT, MM/UNIT)
C     WC     I  MAXIMUM WATER CONTENT OF SNOWPACK BY WEIGHT
C     MPACK  I  ESTIMATED WATER EQUIVALENT OF SNOWPACK FOR COMPLETE COVERAGE
C     EVAPCO I  EVAPORATION FACTORS FOR SNOW EVAPORATION
C     MELEV  I  MEAN ELEVATION OF WATERSHED (FT, M)
C     TSNOW  I  TEMPERATURE BELOW WHICH SNOW FALLS (F, C)
C     PACK   I  INITIAL WATER EQUIVALENT OF SNOWPACK (IN, MM)
C     DEPTH  I  INITIAL DEPTH OF SNOWPACK (IN, MM)
```

```
C
C     ARPERC: PERCENT OF A GIVEN LAND TYPE USE
C     ARPERV: PERCENTAGE OF IMPERVIOUS AREA FOR A GIVEN LAND TYPE USE
C     CONPRO: MONTHLY COVER CONST. FOR A GIVEN LAND TYPE USE
C     PRPVEC: POTENCY FACTORS FOR A GIVEN LAND TYPE - PERVIOUS AREAS
C     PRPMAT: MATRIX OF POTENCY FACTORS FOR MONTHLY VARIATIONS
C             - PERVIOUS AREAS, 12 VALUES PER CONSTITUENT
C     PRIVEC: POTENCY FACTORS FOR A GIVEN LAND TYPE - IMPERVIOUS AREAS
C     PRIMAT: MATRIX OF POTENCY FACTORS FOR MONTHLY VARIATIONS
C             - IMPERVIOUS AREAS, 12 VALUES PER CONSTITUENT
C     PEP   : PRECIPITATION EROSION FACTOR DEALING RUNOFF AND
C             AIR POLLUTANTS
C     JRER  : EXPONENT IN RAINDROP SOIL SPLASH EQUATION
C     KRER  : COEF. IN RAINDROP SOIL SPLASH EQUATION
C     JSER  : EXPONENT IN WASH OFF FUNCTION FOR PERVIOUS AREAS
C     KSER  : COEF. IN WASH OFF FUNCTION FOR PERVIOUS AREAS
C     JSIR  : EXPONENT IN WASH OFF FUNCTION FOR IMPERVIOUS AREAS
C     KSIR  : COEF. IN WASH OFF FUNCTION FOR IMPERVIOUS AREAS
C     ACOIT : ACCUMULATION RATES - IMPERVIOUS AREAS
C     ACUIV : MONTHLY ACCUMULATION RATES - IMPERVIOUS AREAS, 12 VALUES
C     ACOP  : ACCUMULATION RATES - PERVIOUS AREAS
C     ACUPV : MONTHLY ACCUMULATION RATES - PERVIOUS AREAS, 12 VALUES
C     REMIP : REMOVAL COEF. - IMPERVIOUS AREAS
C     REMIPV: MONTHLY REMOVAL COEF. - IMPERVIOUS AREAS, 12 VALUES
C     REMPV : REMOVAL COEF. - PERVIOUS AREAS
C     REMPRV: MONTHLY REMOVAL COEF. - PERVIOUS AREAS, 12 VALUES
C     SNOPI : INITIAL AMOUNT OF PICRU AVAILABLE FOR TRANSPORT
C     PSI   : INITIAL AMOUNT OF SOLIDS AVAILABLE FOR TRANSPORT
C
      READ (5,9520) (WDNAME(I),I=1,6)
      READ (5,9000)
      READ (5,9010)
      READ (5,9020)
      READ (5,9030)
      READ (5,9040)
      READ (5,9050)
      READ (5,9060)
      READ (5,9070)
      IF (NHOUR.EQ.1) GO TO 80
      GO TO 90
   80 READ (5,9080)
      READ (5,9090)
      READ (5,9100)
      READ (5,9110)
      READ (5,9120)
      READ (5,9130)
   90 READ (5,9140)
      DO 10 I=1,NQUAL
   10 READ (5,9150) (QUALID (I,J),J=1,3),CONVER(I)
      DO 20 I=1,NLAND
      READ (5,9160) (LANDUSE(M,I),M=1,3)
      READ (5,9170)
      READ (5,9180)
      ARPERI=ARPERV
      ARPERV=100.-ARPERI
      DO 20 I=1,12
   20 CONVAR(I,I)=CONPRO(I)
C
      DO 21 I=1,12
      DO 21 J=1,12
      IF(I.EQ.J) GO TO 21
      PRPMAT(I,J)=0.0
      PRIMAT(I,J)=0.0
   21 CONTINUE
C
      IF (NRAIN.EQ.1) GO TO 30
C
```

```
C          READ INPUT DATA OF ACCUMULATION RATES, REMOVAL RATES, AND
C          DECAY RATIOS WITHOUT MONTHLY VARIATION
C
      READ (5,7777)
      READ (5,7888)
      READ (5,7999)
      DO 50 I=1,NQUAL
      PRINT#(I+1,11,NUMBER):PRPROD(I,J)
   50 PRINT#(I+11,11,NUMBER):DRIVOC(I,J)
      ACUPC(I,NUMBER)=ACUP
      ACUTR(I,NUMBER)=ACUT
      REMPR(I,NUMBER)=REMAR
      DRIVR(I,NUMBER)=DRIAR
      GO TO 65
C
C          READ INPUT DATA OF ACCUMULATION RATES, REMOVAL RATES, AND
C          DECAY RATIOS WITH MONTHLY VARIATION
C
   60 READ (5,8878)
      READ (5,8888)
      READ (5,8898)
      DO 73 I=1,NQUAL
      DO 73 NN=1,12
      PRPTAR(I+1,11,NN)=PRPRAT(NN,I)
   73 DRIVA(I+11,11,NN)=DRIMAT(NN,I)
      DO 83 NN=1,12
      ACUPR(I,NN)=ACUPC(NN)
      ACUTR(I,NN)=ACUTR(NN)
      REMPR(I,NN)=REMPR(NN)
   83 DRIVR(I,NN)=DRIAR(NN)
   65 CONTINUE
      READ (5,8868)
      DRIVC(I)=DRIAR
      TS(I)=TSR
  100 CONTINUE
      IF (UNIT .EQ. -1) GO TO 120
      DPRM=UNIT(1,1)
      WRUT=UNIT(1,1)
      SRT=UNIT(1,1)
      DPI=UNIT(2,1)
      DTRP=UNIT(1,1)
      ABUS=UNIT(2,1)
      RUN=1
      GO TO 110
  120 DPRM=UNIT(2,2)
      WRUT=UNIT(1,2)
      SRT=UNIT(1,2)
      DPI=UNIT(2,2)
      DTRP=UNIT(1,2)
      ABUS=UNIT(2,2)
      RUN=2
C
C                    PRINTOUT OF TITLE PAGE AND INPUT PARAMETERS
C
  110 WRITE (6,9870)
      WRITE (6,9893) (NAME(I),I=1,5),ABUS,ABUS
      WRITE (6,9900) ABUS,ABUS,ABUS
      APP1=1.0
      APP2=0.0
      DO 153 I=1,NLAND
      TCH=AREA*APP1(I)
```

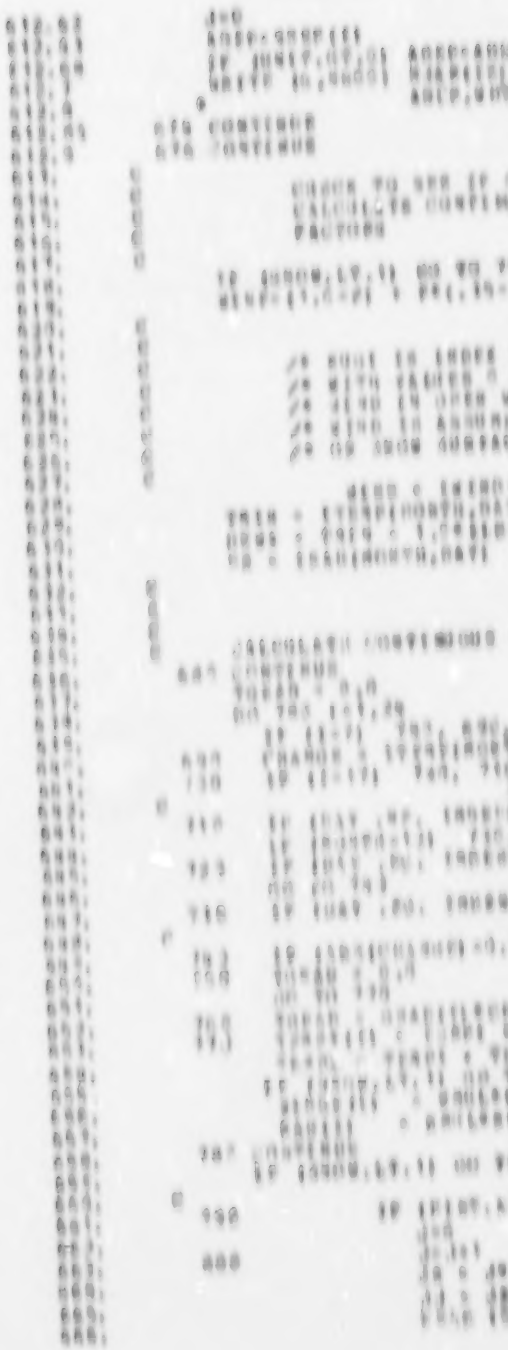
```
C
C                    PRINTING OF SIMULATION CHARACTERISTICS
C
  150 IF(NOSIM.EQ.1) GO TO 200
      WRITE (6,9150)
 9150 FORMAT(1H1,'SIMULATION CHARACTERISTICS'//)
      WRITE (6,9151) NOSIM,NOSIM,NOSIM,NOSIM,NOSIM,NOSIM
 9151 FORMAT(1H ,'NOSIM=',I2,'  NOSIM=',I2,'  NOSIM=',I2,'  NOSIM=',I2,
     1'  NOSIM=',I2,'  NOSIM=',I2//)
      WRITE (6,9152) (I,NOSIM(I),I=1,NOSIM)
 9152 FORMAT(1H ,'NOSIM(',I2,')=',I2)
      WRITE (6,9153) (I,NOSIM(I),I=1,NOSIM)
 9153 FORMAT(1H ,'NOSIM(',I2,')=',I2)
      WRITE (6,9154) (I,NOSIM(I),I=1,NOSIM)
 9154 FORMAT(1H ,'NOSIM(',I2,')=',I2)
      WRITE (6,9155) (I,NOSIM(I),I=1,NOSIM)
 9155 FORMAT(1H ,'NOSIM(',I2,')=',I2)
      WRITE (6,9156) (I,NOSIM(I),I=1,NOSIM)
 9156 FORMAT(1H ,'NOSIM(',I2,')=',I2)
      WRITE (6,9157) (I,NOSIM(I),I=1,NOSIM)
 9157 FORMAT(1H ,'NOSIM(',I2,')=',I2)
C
C  PRINTING OF SCRATCH COVER FUNCTION, LOSS  AND V/S CORRECTION FACTORS
C
  200 WRITE (6,9158) (NOSIM(I),I=1,NOSIM),(TCF(I),I=1,10),
     1         (LOSS(I),I=1,10),
     2         (LOSS(I,K),K=1,10),I=1,10)
```

```
```

```
C
C                    ADJUSTMENT OF CONSTANTS
C
  350 U = U0/1097.91
      TEMPAC = 1097.91
      INTEVL = 2498
      ADJ1=0.0
      DO 351 I=1,NUMLAT
      IF (CURLAT(I).EQ.TABLAT(I)) CURLAT(I)=CURLAT(I)+0.01
  351 IF (CURLAT(I).EQ.CURLAT(I+1)) CURLAT(I)=1000.
      IF (NUMLAT.EQ.1) GO TO 353
      I1=(I1+1)*ALT0
      DO 352 I=I1,I2
  352 TABLE(I)=ALT0(I)
  353 I=NUMLAT
      T(I)=ALT0(I)
      J=1
      DO 354 I=15,99,6
      J=J+1
      IF(ALT0(I).LT.0.1 ) GO TO 350
      TABLE(J)=ALT0(I)
  354 CONTINUE
C
C          CONVERT SOUNDING DATA INTO TUBE/AUGR/OBS
C
      DO 355 I=1,NLEVS
      IF (ARRAY(I,2).EQ.0) GO TO 360
      AUGR(I,NUMAUG)=AUGR(I,PLUS1)/2000.
      CURLAT(I,NUMAUG)=AUGR(I,NUMAUG)/2000.
      GO TO 365
  360 DO 361 J=1,12
      AUGR(I,J)=AUGR(I,J)/2000.
      AUGR(I,J)=AUGR(I,J)/2000.
  361 CONTINUE
  365 CONTINUE
        PRI=1.0
        TEMP=TEMP+(1.0/98.0)
```

```
      IF (ISEQ4 .LT. 1)  GO TO 450
        DO  430 DA = 1,31
  425   READ(5,4050)  (ISEAD(HR,DA), HR=1,19)
C
        DO 440 DA =1,31
  440   READ (5,4050)  (IDEAD(HR,DA), HR=1,19)
C
  450   IF (ORUN .EQ. 1) GO TO 490
        DO 480 DA=1,31
           DO 470 HR=1,19
             IEVAP(HR,DA) = IEVAP(HR,DA)*1.017
             IF (ISEQ3.EQ.1) IRIGD(HR,DA) = IRIGD(HR,DA)*0.6214
             DO 460 IY=1,3
  460          IYEAP(HR,DA,IY) = 1.8*IYEAP(HR,DA,IY) + 32.0
  470        CONTINUE
  480      CONTINUE
C                                                  DAY THIS OF JAN 1 OR 11/11
  490 IYEAP(11,31,3) = IYEAR(1,1,3)
C
C
C
C                                                          BEGIN MONTHLY LOOP
  501   DO 1250  MONTH=MSTART,MSTOP
C
C           ASSIGN CURRENT MONTHLY VALUES OF ACCUMULATION RATES,
C           REMOVAL RATES, AND OUTPUT FACTORS
C
      IF (ISTOAL.EQ.1) GO TO 530
      IF (ANRAIN.EQ.0.AND.MONTH.NE.NORMON) GO TO 530
      DO 520 I=1,NLAND
      DO 510 J=1,NQUAL
      PREC(I,J)=PRTAR(J,I,MONTH)
  510 PRI(I,J)=PRITAR(J,I,MONTH)
      ACCP(I)=ACCPR(I,MONTH)
      ACCI(I)=ACCIR(I,MONTH)
      EPIR(I)=EPIRR(I,MONTH)
  520 PIRR(I)=PIRRR(I,MONTH)
  530 CONTINUE
      TEMPCD=TCF(MONTH)
C
C                    ORDERING OF VARIABLES
C
      DO 550 I=1,20
C          ORDERING OF THE FIRST 20 VARIABLES CONTAINED IN COMMON/LABCOM/
  540 ABIOMF(I)=0.0
      PORMIC=
      PORTOR=0.
      IRFOOD=0.
      DO 560 J=1,NQUAL
      DO 550 I=1,NLAND
      APOLF(I,J)=0.0
      APOLI(I,J)=0.0
  550 CONTINUE
      POLTOA(J)=0.0
  560 POLTO(J)=0.0
      DO 570 I=1,NLAND
      AEROF(I)=0.0
      AEROI(I)=0.0
  570 CONTINUE
      BODIN=0
      BODIO=0
```

```
                  TEMPA=0.0
                  DOA=0.0
                  SELTOL=0.0
                  IX=JMONTH
                  IX=IX-1
                  RECOUT(1)=YEAR
                        DYSTRT = 1
                        IF (MOD(YEAR,4)   595, 585, 595
     585              GO TO (610,610,630,630,630,630,630,630,630,630,630,630),
                    *MONTH
     595              GO TO (610,650,610,630,610,630,630,610,610,630,630,630),
                    *MONTH
     600                 DYEND = 28
                         GO TO 640
     610                 DYEND = 29
                         GO TO 640
     620                 DYEND = 30
                         GO TO 640
     630                 DYEND = 31
C
     640            IENDAD=DYEND
                    IF (YEAR .NE. PREYR)   GO TO 650
                    IF (MONTH .NE. PREMON)   GO TO 650
                    DYSTRT = PDAY+1
C
     651            IF (YEAR .NE. PREYR)   GO TO 660
                    IF (MONTH .NE. PREMON)   GO TO 660
                    DYEND = PREDAY
                                                                  BEGIN DAILY LOOP
C
     660            DO 990  DAY=DYSTRT,DYEND
C
                       IF (MONTH.EQ.1 .AND. DAY.EQ.1) JCUMDY = 0
                       JCUMDY = JCUMDY + 1
C
                       TIME = 0
                       RAIDY = 0.0
                       DP = DEPTOL*(DEVAP(MONTH,DAY)/1000.
                       DO 670   I=1,INTPTS
                          IRAIN(I) = 0
                          RAIN(I) = 0.0
     670                  CONTINUE
C
          MTH=MONTH
          DYS=DAY(I)
          IF (DYS.GT.32) DYS=1
C
C         CALCULATE RRSMI FOR EACH DAY AS LINEAR INTERPOLATION
C         BETWEEN MONTHLY VALUES
C
          RRSMI=(RRSM(MTH)+(RRSM(NTH)-RRSM(MTH))*(FLOAT(DAY)-1)/
         *      FLOAT(DYEND))
C
C
C            CHECK FOR STORAGE RATES AND ADJUST OUTS
C
          JC=1
          DO 675 I=1,NSAMP
          DO 675 IC=1,12
          IF (JCUMDY.EQ.TSTART(I,IC))  GO TO 675
          JBACK=IC
          JC=IC-1
          IF (DY.GT.0) QOUT(I)=QOUT(I)
```



```
                  IF (WUNIT .EQ. -1) GO TO 830
                  DO 810 I=1,36
                     IRAIN(I) = IRAIN(I)*1.937 + 0.5
                  CONTINUE
      810
      820         IF (CS .EQ. 0)  J=0
                  YR = YR + 1900
                  IT = (YEAR-78) * (MONTH-80) + (DAY-80) + (J-C8)
                  IF (IT .EQ. 0)  GO TO 812
                  WRITE (6,5000)  J, MONTH, DAY, YEAR, C8, HO, DY, YR
                  GO TO 1600
      812         IF (J.LT.0)  GO TO 830
                  DO 840  I=1,INTVAL
                     RAIN(I) = IRAIN(I)*1/100.
                     RAINT = RAINT + RAIN(I)
      840         CONTINUE
                  GO TO 920
C
C                                                   HOURLY PRECIP INPUT
C
      850         J=0
      860         J=J+1
                  JR = J+240
                  JJ = JR + 47
                  READ (5,5020)  YR, MO, DY, CR, (IRAIN(I), I=JJ,JR,8)
                  IF (WUNIT .EQ. -1) GO TO 880
                  DO 870 I=JJ,JR,8
                     IRAIN(I) =IRAIN(I)*1.937 + 0.5
                  CONTINUE
      870         IF (CS .EQ. 0)  J=0
      880         YR = YR + 1900
                  IT = (YEAR-78) * (MONTH-80) + (DAY-80) + (J-C8)
                  IF (IT .EQ. 0)  GO TO 890
                  WRITE (6,5000)  J, MONTH, DAY, YEAR, C8, HO, DY, YR
                  GO TO 1600
      890         IF(J.LT.2)  GO TO 850
C
                  DO 910  I=1,INTVAL,8
                     TEN = IRAIN(I)*10/100.1/8.
                     DO 900 K=1,8
                     RAIN(I+K-1)=TEN
                     RAINT = RAINT + RAIN(I)
      900            CONTINUE
      910         CONTINUE
C
      920      IF (RAINT)  930, 910, 950
C
C  USE RAIN LOOP IF SNOWMELT STORAGES ARE NOT EMPTY
C
      930   IF (ISURO .LT. 0.001).OR.(ISBOT .LT. 0.001)) GO TO 980
C
C                  RAIN LOOP
C
C     CONDITIONAL BRANCHING TO CALCULATE HOURLY TEMPERATURES
C
      940   IF (ISNOW.LT.1) GO TO 960
      950   CONTINUE
C
C       CALCULATE COVER FUNCTION  FOR THE PERVIOUS
C             AREAS WITHIN EACH LAND USE USE
C
            MO=MONTH
            DY=NUMDAY
            IF (NYR.GT.0)  NYR=1
```

```
      DO 900 I=1,NLAND
      COVAR(I)=(CONVAR(I,2)+(FLOAT(IRAT-1)/FLOAT(IYEARS))*
     1         (CONVAR(I,NYL)-CONVAR(I,2))
  900 CONTINUE
                  DO 975  I=1,INTRVL
                     PIAN = PIAN + 1
                     PP = 1
                     PR = RAIN(I)
C
                     RAIN = RODITIME,RI
                     IRUN = (TIME - ININ)/H
                     IMIN = TIMEAC*IMIN
                     II = IMONTH
                     IE = IE - 1
                    CALL LABOR
            IF (CITCAL.EQ.1) GO TO 975
                     CALL QUAL
  975 CONTINUE
                     RRRR=0
C
                  GO TO 990
C
C                      NO RAIN LOOP
C
  985             PP = INTRVL
                  PR = 0.0
                  PI = 0.0
                     RRUN1 = 0.0
                  IMIN = 00
                  IRR = 24
                  II = IMONTH
                  IE = IE - 1
                   IRRR=NUMRI
                   CALL LABOR
            IF (INTCAL.EQ.1) GO TO 990
                   CALL QUAL
C                                                    END RAIN LOOP
  990             CONTINUE
C
C                                 MONTHLY SUMMARY
C
      WRITE (5,9101) RRAP(II),RNAM(II),YEAR
      URRUT=URR
      LRRUT=LRR
      RURUT=RRR
      RCRRUT=RCRR
      PRRRUT=RRRR
      SRRRRU=RRRRT
      TMRAL=TMRAL
      PARM(1)=TMRAL
      PAURUT=PAUR
      IF (IRUN.EQ.-1) GO TO 1010
      DO 1000 I=1,28
C          CONVERSION TO METRIC UNITS OF THE FIRST 28 VARIABLES
C          CONVERSION TO COMMON/LABOUR/
      ARIOUT(I)=ARIOUT(I)*PARM(I)
 1000 CONTINUE
 1010 WRITE (6,9110) RRRR,RRRRCR,RRRRUR,RIRUR,RRRFUR,RURUR,RCRFUR,PRRUR
      IF (IRUN.GT.1) GO TO 1030
      COVAR=100.
      IF (SPACR.LT.1SPACR) COVAR=(SPACR/1SPACR)*100.
```

```
C
C          OUTPUT OF SEDIMENTS REMOVED OR CARRIED AT MONTH'S END
C
      WRITE (6,9170) MNT,ARUN
      TERA=0.0
      TERB=0.0
      TERC=0.0
      TERD=0.0
      DO 1060 I=1,NLAND
      TERA=TERA+(SED(I,1)-SED(I,2))*FR(I)*AREA(I)
      SEDOUT=(SED(I,2)/SED(I,1))*ERER(I)
      SEDOUTB=(SED(I,2)/SED(I,1))*ERER(I)
      TERB=TERB+SED(I,2)*SEDOUT
      TERC=TERC+SED(I,2)*SEDOUTB
      TERD=TERD+SED(I,2)
      IF (UNIT.GT.1) GO TO 1050
      WRITE (6,9190) (LNDUSE(I,1),I=1,3),TERA,TERB(I),TD(I)
      GO TO 1060
 1050 TERA=SED(I,2)*2.24
      TERB=TD(I)*2.24
      TERC=TERC*2.24
      WRITE (6,9191) (LNDUSE(I,1),I=1,3),TERA,TERB,TERC
 1060 CONTINUE
      IF (ILAND.EQ.1) GO TO 1070
      IF (TERB.GT.0.0) TERA=TERA/TERB
      IF (TERB.LE.0.0) TERA=0.0
      IF (TERB.GT.0.0) TERC=TERC/TERB
      IF (TERB.EQ.0.0) TERC=0.0
      TERA=TERA*(1.-A)+TERA*A
      IF (UNIT.EQ.1) GO TO 1080
      TERA=TERA*2.24
      TERB=TERB*2.24
      TERC=TERC*2.24
 1080 WRITE (6,9192) TERA,TERB,TERC
C
C          OUTPUT MONTHLY SEDIMENTS LOSS FOR EACH LAND TYPE USE
C
 1070 WRITE (6,9193) MNT,MNUP,ARUN
      AUNIT=0.0
      AUTEP=0.0
      DO 1100 I=1,NLAND
      TERA=AREA(I)*AFUNE(I)
      IF (TERA.GT.0.0) GO TO 1090
      TERB=0.0
      TERC=0.0
      TERD=0.0
      GO TO 1100
 1090 TERB=SED(I,2)*2.24/ARUN
      TERC=TOC*SED(I,2)/ARUN
      TERD=(1.-RARE(I))*TERA
      TERA=TERA*RARE(I)/TERA
      IF (UNIT.EQ.1) GO TO 1095
```

```
      TERM=TERM+YSTZ
      TZER=TZER+01.12
 1000 WRITE (6,6011) (LINDUSE(K,I),K=1,3),I,PIR,TERM,TERZ,TERR
      AERO(I)=AERO+ANTHAERO(I)
      AERR(I)=AERR+ANTHAERR(I)
 1100 CONTINUE
C
C          OUTPUT MONTHLY SEDIMENT LOSS FOR THE ENTIRE WATERSHED
C
      TERR=AERO+ANTHAERR
      IF (TERR.GT.0.0) GO TO 1110
      TERR=0.0
      TERZ=0.0
      TERM=0.0
      GO TO 1120
 1110 TERR=TERR*2000./AREA
      TERZ=TERZ.*ESTIMAT/TERR
      TERM=TERM.*ESTIMAT/TERR
      IF (TERR.LT.1) GO TO 1120
      TERR=TERR+.5072
      TERR=TERR*01.12
 1120 WRITE (6,6010) TERR,TERM,TERZ,TERR
      WRITE (6,6021) RAIN ,RAIN,AREA
C
C          OUTPUT MONTHLY WASHOFF FOR EACH OF THE ANALYZED POLLUTANTS
C
      DO 1180 J=1,NQUAL
      WRITE (6,6031) (QUALID(I,J),I=1,3)
      APOLLT=0.0
      APOLLT=0.0
      DO 1150 I=1,NLAND
C
C          MONTHLY WASHOFF OF A GIVEN POLLUTANT FROM EACH LAND TYPE USE
C
      TERR=APOLLP(I,J)*APOLLE(I,J)
      IF (TERR.GT.0.0) GO TO 1130
      TERM(I)=0
      TERZ=0.0
      TERR=0.0
      GO TO 1140
 1130 TERM(I)=TERR/AU(I)
      TERR(I)=0.*APOLLP(I,J)/TERR
      TERZ(I)=0.*APOLLE(I,J)/TERR
      IF (TERR.LT.1) GO TO 1140
      TERR=TERR+.550
      TERR(I)=TERR/ROOMA
 1140 WRITE (6,6012) (LINDUSE(K,I),K=1,3),I,TERR,TERM,TERZ,TERR
      APOLLP=APOLLP+APOLLP(I,J)
      APOLLE=APOLLE+APOLLE(I,J)
 1150 CONTINUE
C
C          TOTAL MONTHLY WASHOFF OF A GIVEN POLLUTANT
C
      TERR=APOLLP*APOLLE
      IF (TERR.GT.0.0) GO TO 1160
      TERM=0.0
      TERZ=0.0
      TERR=0.0
      GO TO 1170
 1160 TERM=TERR/AREA
      TERZ=TERR.*APOLLP/TERR
```

```
                TEMX=100.*AMPULE/TEM
                IF (UNITF.LT.1) GO TO 1170
                TEM=(TEM-32.)*5./9.
                TEMP1=TEM1/SQRNA
      1170 WRITE (6,9400) TEM,TEM1,TEM2,TEM3
      1180 CONTINUE
                TEMPAV=TEMPAV+TEMPA
                DOAV=DOAV+DOA
                SEETCV=SEETCV+SEETCA
C
C          CALCULATE AND PRINT MONTHLY AVERAGES OF TEMPERATURE,
C          DISSOLVED OXYGEN,AND EACH OF THE ANALYZED POLLUTANT
C
                IF (NLOOP.LE.1) GO TO 1190
                TEMPA=TEMPA/NOBSR
                DOA=DOA/NOBSR
                SEETCA=SEETCA/NOBSR
      1190 TEMPO=TEMPA
                IF (UNITF.EQ.1) TEMPO=(TEMPO-32.)*5./9.
                WRITE (6,9450) UTM1,TEMPO,DOA,SEETCA
                DO 1210 J=1,NOMAL
                PLTCAV(J)=PLTCAV(J)+POLTCA(J)
                IF (NOBSR.LE.1) GO TO 1200
                POLTCA(J)=POLTCA(J)/NOBSR
      1200 WRITE (6,9451) (QUALITE(I,J),I=1,3),CONST(J),POLTCA(J)
      1210 CONTINUE
C
C                    ACCUMULATION FOR YEARLY SUMMARIES
C
                DO 1220 I=1,NLAND
                AVDOYY(I)=AVDOYY(I)+AVDOX(I)
                AVTMYY(I)=AVTMYY(I)+AVTEM(I)
                DO 1220 J=1,NOMAL
                AVQLYY(I,J)=AVQLYY(I,J)+AVQLPR(I,J)
                AVPLYY(I,J)=AVPLYY(I,J)+AVPLIN(I,J)
      1220 CONTINUE
      1230 CONTINUE
                WRITE (6,9452) MON
                NOBSYR=NOBSYR+NOBSR
                NUSE=NUSE+NOS
      1240 CONTINUE
                                        END MONTHLY LOOP
C                                  YEARLY SUMMARIES
C
                WRITE (6,9400) YEAR
                DFSAT=DFS
                LSCMT=LSD
                SOVRT=SOV
                SLUDI=SLUP
                DISSF=DSOX
                SBOXYT=SBOX
                TMSLAT=TMBAL
                TOMOIL=TOBAL
                IF (UNITF.EQ.1) GO TO 1260
                DO 1250 I=1,20
C               CONVERSION TO METRIC UNITS OF THE LAST 20 VARIABLES
C               CONVERTED IN SUBROUTINE/LABOUT/
      1250 ARROUT(I)=ARROUT(I)*FACTOR
      1260 WRITE (6,9110) DFSAT,SLUDI,DISSF,LSCMT,SOVRT,SBOXYT,PSTOR
                IF (UNITF.EQ.1) GO TO 1280
                CONV=100.
```

```
C
C          OUTPUT YEARLY SEDIMENTS LOSS FOR EACH LAND TYPE USE
C
      ASEDUSE=0.0
      ASEDT=0.0
      DO 1310 I=1,NLAND
      TEM=ASEDT(I)+ASEDUSE(I)
      IF (TEM.GT.0.0) GO TO 1240
      TEM1=0.0
      TEM2=0.0
      TEM3=0.0
      GO TO 1300
 1240 TEM1=TEM/AREA(I)
      TEM1=100.*ASEDUSE(I)/TEM
      TEM2=100.*ASEDOUT(I)/TEM
      IF (UNIT.EQ.1) GO TO 1250
      TEM=TEM*.0572
 1250 TEM1=TEM1/SNGMA
 1300 WRITE (6,9001) (LUSE(I,J),J=1,3),I,TEM,TEM1,TEM2,TEM3
      ASEDUSE=ASEDUSE+ASEDUSE(I)
      ASEDT=ASEDT+ASEDT(I)
 1310 CONTINUE
C
C          OUTPUT YEARLY SEDIMENTS LOSS FOR THE ENTIRE WATERSHED
C
      TEM=ASEDUSE+ASEDT
      IF (TEM.GT.0.0) GO TO 1320
      TEM1=0.0
      TEM2=0.0
      TEM3=0.0
      GO TO 1330
 1320 TEM1=TEM/AREA
      TEM2=100.*ASEDUSE/TEM
      TEM3=100.*ASEDT/TEM
      IF (UNIT.EQ.1) GO TO 1330
      TEM=TEM*.0572
      TEM1=TEM1/2.24
 1330 WRITE (6,9002) TEM,TEM1,TEM2,TEM3
      WRITE (6,9003) ENRT,ENRC,ASDR
C
C          OUTPUT YEARLY RUNOFF FOR EACH OF THE ANALYSED POLLUTANTS
C
      DO 1350 J=1,NUMAS
      WRITE (6,9101) (QUALS(I,J),I=1,3)
      APOLP=0.0
      APOLT=0.0
      DO 1340 I=1,NLAND
C
C          YEARLY RUNOFF OF A GIVEN POLLUTANT FROM EACH LAND TYPE USE
C
```

```
      TSS=APOLPT(1,J)*APOLIT(1,J)
      IF (TSS.GT.0.0) GO TO 1140
      TSS1=0.0
      TSS2=0.0
      TSS3=0.0
      GO TO 1150
 1140 TSS1=TSS/AREA
      TSS2=100.*APOLPT/TSS
      TSS3=100.*APOLIT/TSS
      IF (WRITE.LT.1) GO TO 1150
      TSS=TSS*.556
      TSS1=TSS1/SQDMA
 1151 WRITE (6,5510) (LABOUR(KK,1),KK=1,3),TSS,TSS1,TSS2,TSS3
      APOLPT=APOLPT+APOLPT(I,J)
      APOLIT=APOLIT+APOLIT(I,J)
 1160 CONTINUE
C
C          TOTAL YEARLY WASHOFF OF A GIVEN POLLUTANT
C
      TSS=APOLPT+APOLIT
      IF (TSS.GT.0.0) GO TO 1170
      TSS1=0.0
      TSS2=0.0
      TSS3=0.0
      GO TO 1180
 1170 TSS1=TSS/AREA
      TSS2=100.*APOLPT/TSS
      TSS3=100.*APOLIT/TSS
      IF (WRITE.LT.1) GO TO 1180
      TSS=TSS*.556
      TSS1=TSS1/SQDMA
 1180 WRITE (6,5440) TSS,TSS1,TSS2,TSS3
 1190 CONTINUE
C
C          CALCULATE AND PRINT YEARLY AVERAGES OF TEMPERATURE,
C          DISSOLVED OXYGEN,AND EACH OF THE ANALYZED POLLUTANTS
C
      IF (WRITE.LE.0) GO TO 1200
      TEMPAV=TEMPAV/NOSIM
      DOAV=DOAV/NOSIM
      BODTOV=BODTOV/NOSIM
 1200 TEMPAV=TEMPAV
      IF (WRITE.EQ.1) TEMPAV=(TEMPAV-32.)*5./9.
      WRITE (6,5450) DOAV,TEMPAV,BODAV,BODTOV
      DO 1205 J=1,NOWAL
      IF (NOSIM.LE.0) GO TO 1210
      PLTAV(J)=PLTAV(J)/NOSIM
 1210 WRITE (6,5460) (POLLUT(I,J),I=1,3),CONV(J),PLTAV(J)
 1220 CONTINUE
 1225 WRITE (6,5470) NOSIM
C
C                         RESETTING OF VARIABLES
C
      DO 1230 I=1,20
C          RESETTING OF THE LAST 20 VARIABLES CONTAINED IN COMMON/LABOUR/
 1230 ARRAY(I)=0.0
      DO 1250 J=1,NOWAL
      DO 1250 I=1,5
      APOLPT(I,J)=0.0
 1252 APOLIT(I,J)=0.0
 1250 PLTOUT(I)=0.0
```

```
      DO 1550 I=1,5
      AVERAGE(I)=0.0
 1550 SUMSQ(I)=0.0
      NOBS=0
      TEMPAV=0.0
      OBAV=0.0
C
C        SUMMARY OF STORAGE CHARACTERISTICS
C
      OPEN(UNIT=10,
     1FILE='STORAGE.DAT',STATUS='OLD')
      IF (EOF(10)) GO TO 1560
      IF (NOBS.LT.2.OR.NOBS.GT.200) GO TO 1560
C
C        CLEAR OUTPUT VECTORS AND INITIALIZE TOTAL AND TRAN
C
      DO 1570 I=1,NOBS
      TOTAL(I)=0.0
      OBS(I)=0.0
      TRAN(I)=1.0875
 1570 TRANSF(I)=1.0875
C
C        CALCULATE SPANS, ST.DEV'S,RADIRA, AND RATIOS
C
      DO 1520 I=1,NOBS
      DO 1520 K=1,NV
      TOTAL(I)=TOTAL(I)+STORCH(I,K)
      IF (STORCH(I,K)-MEAN(K)) 1500,1490,1490
 1490 SUMSQ(K)=SUMSQ(K)+
 1500 IF (STORCH(I,K)-MEAN(K)) 1510,1510,1520
 1510 TRANSF(K)=STORCH(I,K)
 1520 SD(K)=SD(K)+STORCH(I,K)*STORCH(I,K)
 1530 CONTINUE
      DO 1540 K=1,NV
      RANGE(K)=TRANS(K)-TRANS(K)
      AVERAGE(K)=TOTAL(K)/NOBS
      SD(K)=SQRT(ABS((SD(K)-TOTAL(K)*TOTAL(K)/NOBS)/(NOBS-1)))
 1540 CONTINUE
C
C        PRINT STORM CHARACTERISTICS
C
      IF (EOF(10)) GO TO 1560
      WRITE (6,9500)
      WRITE (6,9501) DURA,AVERAGE(1),SD(1),TRANS(1),TRANSF(1),RANGE(1)
      WRITE (6,9502) DEPT,AVERAGE(2),SD(2),TRANS(2),TRANSF(2),RANGE(2)
      DO 90 I=3,5
 1560 WRITE (6,9500)
      WRITE (6,9510)
      WRITE (6,9503) RAT,AVERAGE(3),SD(3),TRANS(3),TRANSF(3),RANGE(3)
      WRITE (6,9504) RAT1,AVERAGE(4),SD(4),TRANS(4),TRANSF(4),RANGE(4)
      WRITE (6,9505) AVERAGE(5),SD(5),TRANS(5),TRANSF(5),RANGE(5)
      WRITE (6,9506) AVERAGE,SD,TRANS,TRANSF,RANGE
      DO 1561 I=1,NOBS
      WRITE (6,9511) (STORCH(I,K),K=1,5)
      IF(OBS(I)) 1561,1561,1562
 1562 WRITE (6,9507) RAT,AVERAGE(3),SD(3),TRANS(3),TRANSF(3),RANGE(3)
      IF(OBS(I)-1.) 1561,1563,1563
 1563 WRITE (6,9508) RAT1,AVERAGE(4),SD(4),TRANS(4),TRANSF(4),RANGE(4)
      IF(OBS(I)-2.) 1561,1564,1564
 1564 WRITE (6,9509) AVERAGE(5),SD(5),TRANS(5),TRANSF(5),RANGE(5)
 1561 CONTINUE
```

```
1515 CONTINUE
     GO TO 1570
1560 WRITE (6,5570)
     IF (NOST.EQ.0) GO TO 1590
1570 DO 1580 I=1,NOST
     DO 1580 J=1,NY
1580 STC(I,J)=0.0
     NOST=0
C                                  END OF YEARLY LOOP
1590    CONTINUE
C
1600 CONTINUE
C
C                     FORMAT STATEMENTS
C
4000 FORMAT ('1','**********ERROR****** INCORRECT INPUT DATA! [illegible]',
    *  'CARD ',I1,' FOR ',I2,'/',I2,'/',I4,'; READ CARD ',I1,' FOR ',
    *  I2,'/',I2,'/',I4)
5010 FORMAT [illegible]
5020 FORMAT [illegible]
5030 FORMAT [illegible]
5050 FORMAT [illegible]
5060 FORMAT [illegible]
5070 FORMAT ('1',3(/),45X,'NONPOINT SOURCE POLLUTANT LOADING MODEL',
    1        [illegible])
5080 FORMAT (/,' ',5X,'WATERSHED CHARACTERISTICS :',///,8X,'NAME',8X,
    1        [illegible],'TOTAL AREA (',A6,')',[illegible])
5090 FORMAT ([illegible]'LAND USE',[illegible]'% OF TOTAL',[illegible]'AREA (',A6,')',[illegible]
    1        'PERVIOUS (',A6,')',[illegible]'IMPERVIOUS (',A6,')',[illegible]
    2        'IMPERVIOUS (%)',/)
5100 FORMAT [illegible]
5110 FORMAT (/,5X,'FRACTION OF IMPERVIOUS AREA',[illegible])
5120 FORMAT ([illegible],'CHECK IF THE LAND TYPES AREAS ',
    1        'ARE CORRECT')
5130 FORMAT (5(/),' ',5X,'SIMULATION CHARACTERISTICS :',///,8X,
    1        'TYPE OF RUN',[illegible],'DATE SIMULATION BEGINS',
    2        [illegible]'DATE SIMULATION ENDS',[illegible]
    3        [illegible]'INPUT PRECIPITATION TIME INTERVAL',
    4        [illegible]
    5        [illegible]
    6        [illegible]
    7        [illegible]
    8        [illegible]
    9        [illegible])
5140 FORMAT [illegible]
    1        [illegible]
    2        [illegible]
    3        [illegible]
    4        [illegible]
    5        [illegible]
    6        [illegible]
    7        [illegible])
5150 FORMAT [illegible]
    1        [illegible]
    2        [illegible]
    3        [illegible]
    4        [illegible]
    5        [illegible])
5160 FORMAT [illegible]
    1        [illegible])
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 9970 FORMAT (' ',10X,'TOTAL LOSS',10X,F10.3,/,10X,F10.3)
 9980 FORMAT (' ',25X,'SUMMARY FOR ',I5,/,25X,16('='),//,30X,'TOTAL')
 9990 FORMAT (10(' ',8X,'NO. OF STORMS',10X,I5))
 9500 FORMAT (/,'0',8X,'SUMMARY OF STORMS'' CHARACTERISTICS',98,
     1       'AVERAGE',8X,'SD',8X,'MAXIMA',8X,'MINIMA',
     2       98,'RANGE',/)
 9510 FORMAT (11X,'GROUNDWATER LOSS')
 9520 FORMAT (3A8/4A8)
 9530 FORMAT (/,14X,'TOTAL RUNOFF (',A8,'):',8X,3(5X,F10.3))
 9540 FORMAT (14X,'MAX RUNOFF (',A8,'/(SQ.MI)',6X,F10.3,
     1       9(5X,F10.3))
 9545 FORMAT (14X,'MEAN CONCENTRATION (GM/L)',8X,F10.3,9(5X,F10.3))
 9550 FORMAT (14X,'MEAN CONCENTRATION (',A8,'/L)',6X,F10.3,9(5X,F10.3))
 9555 FORMAT (14X,'MAX CONCENTRATION (GM/L)',8X,F10.3,9(5X,F10.3))
 9560 FORMAT (14X,'MAX CONCENTRATION (',A8,'/',6X,F10.2,9(5X,F10.2))
 9570 FORMAT (/,'0',8X,'**WARNING**',98,
     1       'SUMMARY OF STORM CHARACTERISTICS NOT PRINTED',
     2       /,23X,'NUMBER OF STORMS LESS THAN 3 OR MORE THAN 500',
     3       /,23X,'CHECK YOUR INPUT PARAMETER')
 9580 FORMAT (/,14X,'TOTAL RUNOFF (',A8,')',8X,3(5X,F10.3))
 9590 FORMAT (14X,'MAX RUNOFF (',A8,')',12X,F10.3,
     1       9(5X,F10.3))
 9600 FORMAT (/,' ',A8,'-',I2,'-',I2,' - LAND SURFACE DISTURBANCE OCCURS
     * ON ',I5,' OF ',I5,' SUBSEQUENT DEPOSITS ON PREVIOUS AREAS ABOUT 50%',
     * 99,1X,A8,/,/,A8)
 9610 FORMAT ('1')
C
      STOP
      END
      BLOCK DATA
C
C
C                     BLOCK DATA TO INITIALIZE VARIABLES
C
C
C
      IMPLICIT  REAL(A)
C
      DIMENSION SNAM(20),RADI(20),TEMP(20),WIND(20),RAIN(90),
     1          GRAD(20),RAD0(20),WIND0(20)
C
      COMMON /ALL/ BU,CLAIN,DTCAL,DPST,DPST,FIRIAC,LSS,AREA,PERM,PFLAG,
     1             RFS0,ROOD,SNOW,INTP,RUN,RNTF,USSR,PRNCP,RIN,P3,T0,
     2             RUCLW,LAST,PREV,TEMPR,TMA,TMIC,PR,P1,A,DA,UDP,SOIL,
     3             SNEW(5),TSIS,LANDUSE(5),SI,AS(5),QUALITY(5),L,RUSI,PUR,
     4             MONTH,DPL,DTRP,DUT(5),DI,DRY(12),DI,DUT(5),DI,PERM,
     5             WHT,DRPW,RORPI,RAINMI,RRORIS,ARUR,LAYS(5),IRPRIS,
     6             RLAND,RQUAL,STRCH(200,20),RICOUT(5),PLOUT,SCALEP(5),
     7             SNOW,IACP,IDACR
C
      COMMON /LAND/ DAY,PRTR,IRIR,IR,TLRAT,SUM,CRS,RY,LIRCS,LIRS,AITR(9),
     1              USS,TS,USSR,LEAP,INPTL,INTER,ROOT,DRCT,DRCI,TIY(12),
     2              RIRL,RRIR,RIRIL,DP,IPS,R3,IPIRI,RIRR(5),RRRR,RCRP,CRC,
     3              RROPTI,RMPIR,RUPHA,RRTOSP,CCIAC,RCRP(5),RRRR,RAIR,SMC,
     4              RCP,IORR,P,DRS,RC,ARRACR,CPAPOR,ARLRY,(5RRR,DRYRIR,
     5              DPRI,UPDTH,SORTH,TRIR,PIYRAR,RLRIP,RIRR,IRPTOR,
     6              TCUTAL,PCRTCR,RORTOT,RIR,RQTION,RRITCY,PRAR,CCRIT(9),
     7              IAPPOP,RRAR,RAD,RRC(5),PORA(92)
C
      COMMON /OLD/ MONAME(10),ASES,JRER,PORR,IRIR,TIMPCP,(DYRAT(9,10),
     1             RRIR,JRIR,RRRR,ARP(5),ARI(5),ACCP(5),ACCT(5),ARRR(90),
```

```
      &            ORPIO,SI,PRIIO,SI,QSTOW,QNOWT,RSOTA,QIUTT,RRSOTA,
      &            ACPOLO(6,5I,AS'DRR(5I,APOLP(2,5I,ARRRR(5I,COVRR(6),
      &            APOLI(6,5I,  ,IR(5I,ABIR(5I,POLVA(5I,POLVT(5I,
      &            TEMPA,DEA,POLTOA(5I,ATSMT(5I,ADIRT(5I,APOLP(10,5I,
      &            APOLT(6,5I,POLYC(5I,PLTCAV(5I,ACPOLI(6,5I,BIRP(5I
      C
            COMMON /LBBOOT/ BOOTOR,PINTOR,PITOR,BUTOR,BASTOR,BCNTOR,PRTOR,
           1                SUPTOR,ISTOR,RELBAR,RAIRIR,COWRDR,CPORRR,
           2                CRAIOR,DORR,SRROOR,PACBOT,SRTARR,IPTOR,RRPTOR,
           3                UPBOT,LPBOT,ROWCT,ACIPOT,RIRBOT,BRRITO,TMRALO,
           4                ISMBOT,POBTOT,PINTOT,PITOT,BUTOT,PASTOT,RCNTOT,
           5                PRTOT,BURRRT,PRRNT,RELBAT,RADRIT,COMRLT,CORRRT,
           6                CRAIBT,DORT,SRRORT,PACB T,ORVAPI,RPTOT,RIPTOT,
           7                UBRRT,LBRRT,RORRT,RIIPT,RIRRT,BRRITT,TMRLRT
      C
            COMMON /STS/ ACPOLT(5I,PLTRR(5I,POLTRC(5I,PITRRC(5I,
           1             ACSTOT,RRORR,RRDTRC,RRORTC,POTRRR,PRRRRU
      C
            COMMON /INTR/ RTTPRIN,SI,RTTPRI(3I,ORAD,RAIRIR,WINDIR,ACR,OPR,
           1              TEMPIT,DOAT,RORIT,INTRVL,RMUL,RO,L,RR,RMI,LI,RRR,
           2              RMUL,IOOI,RLECTCT,RCPERV(12I,RRIRRV(12I,ACOPV(12I,
           3              ACUIV(12I,IRPRAT(12,5I,PRIRAT(12,5I,PROTRC(5I,
           4              PRLVIC(5I,ACUT,ACUP,PRINI,PIRRR,PRIRTR,
           5              IPLR(12I,PINTIC(12I,RRIRTC(12I,PILRAT(5,10I,
           6              TILRRO(5,12I,RRR(12I,PCP(12I
      C
            INTEGER  UNIT, LNTO, RSCONT, RFLAG, PRINTR
           1 INTEGER TIMTIC, TILDAY, RPR
      C
            LOGICAL LAST, PRRV
      C
            REAL*8   USHLRP,RTTPIR,UTTIR
            REAL  JRRR, IRRR, JRRP, RRIR,RRIR,JRIR
            REAL  LRRR, TRC,  RR,  L,  IIC,  PY,  RIRL,  RRIR,  IRPII,  INTRR
            REAL  IPR,  RJ=RL,  RI,  RRPTOR,  RRPTOT,  ICR,  RWI,  RUGI
            REAL  INPTOR,  INPTCT,  INTP
            REAL  RRRIR,  RRTOPT,  RUPLR,  PUPRR
            REAL  RTU,  RRI,  IRRR
            REAL  RPLBAR,  RELBAT
      C
            DATA  LAST/.FALSR./, PRRV/.FALSR./
            DATA  PRTOT/0.0/
            DATA  PRTOR,PRTA/R*0.0/
            DATA  RUTOT,  BOSTOR,  PITCR,  PINTOR,  RSPTOR/R*0.0/
            DATA  RUTOR,  BOSTOT,  PITCT,  PINTOT,  SUPTOT/R*0.0/
            DATA  RORIOR,  RORVCT,  INPTOR,  INPTOT,  RCITOR,  RCITOT/R*0.0/
            DATA  TMRAL,  RTRO,  RRRRI,  RRRRI,  RRRRI,  RRRR,  IRTP/IRR.0/
            DATA  RRIRI,  RASTOP,  RCNTOR,  RASTOT,  RCITOT/R*0.0/
            DAT,  PPTOR,  RPTOT/R*0.0/
            DATA  PR,  PR,  RRR,  RUR,  RURR,  RIRCR,  RRRT/R*0.0/
            DATA  TIPRAC,  URRR,  LRRR,  IRPIL,  INTRR,  IRC/R*0.0/
            DATA  R,  RRI,  LRR,  RRR,  RRR,  RY,  RIRL,  RIRL,  RRRR/R*0.0/
            DATA  TR,  RI/R*0.0/
            DATA  RPIR,  RPRRI/IIR*0/
            DATA  RRR/11,11,11,10,11,10,11,11,10,11,10,11/
            DATA  TIRTIR,  TILRAT/IR*0/
            DATA  URRR,  TILRRO/IRR*0.0/
            DATA  RIP/1R1.0/
            DATA  PRTRI ,PRTRAR/10,,10/
            DATA  PRTRUR,RRARRU,ACCRRT,LIRRR,RIRTRC,RIRRRC/R*0.0/
            DATA  IRPRLY,PLTRR,PRLVRC,PLTRRC/RR*0.0/
```

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      DATA  MVAR/' JAN', 'FEB', 'MAR', 'APR', 'MAY', 'JUN',' JUL', 'AUG',
     *      'SEP', 'OCT', 'NOV', 'DEC'/
     *      'QUIT '/
     *      'ROOT'/
      DATA  SNOW/25.4/,  PETOUT/0.007/,  POPLG/0.9516/,  PUPHA/0.892/
      DATA  SUMSUM, PRUNA, HALDAS, HALBOR, CORNER, CHAING,PAUS,0.998,
     *      CORNER, BIRD, SPRUCE, SPRUCE, SUMSHT, PINNY, HELOAT,
     *      HADDPY, CORNBY, CORNBY, CHAIBY, SUMY, UNSURE, SPRUCE,
     *      1SHRS1/2360.0/
      DATA  LYTBYL,PRINTR/15,15/,  SNUL,SNUL,AUGI,SPLAG/1.0,1.0,0.0,0/
      DATA  IOS, OPS/2*0.0/
      DATA GRAD/0.04,0.05,0.03,0.02,
     *0.32,0.22,0.14,0.09,0.06,0.04,0.03,0.02,0.16,0.20,0.17,0.13,0.08,0.03,0.01,0.00,
     *0.07,0.1,0.13,0.15,0.13,0.12,0.08/
      DATA RADDIS/0*0.0,0.019,
     *0.081,0.067,0.084,0.102,0.110,0.110,0.110,0.105,0.095,0.081,0.065,
     *0.047,0*0.0/
      DATA WINDIS/2*0.035,0.045,
     *0.037,0.041,0.045,0.050,0.053,0.054,0.053,0.051,0.046,0.039,0.043,
     *0.040,0.034,0.030,0.026,0.035/
      DATA NR,NT/2,2,12,  L,L/6*100./,  SS,SSI/29,91/
      DATA TEMPAT,DOAT,RELDTCA,SECTCY/590.0/,  BOSIY,BOSY/2*0/
      DATA CURTI/5*6HORO/1,6HRO/L,6HOR/L/
      DATA FORM/'HE(I2  ,  6H,E5.  ,  6HXE2.5  ,  6H8,I5  ,  6H   ,5  ,  6H8,'1 ,
     *          6HLB)' ,  6H,E5.  ,  6H'(OR  ,  6H/LI',  6H   ,   ,  6H8,'1 ,
     *          6HLB)' ,  6H,E5.  ,  6H'(OR  ,  6H/LI',  6H   ,5  ,  6H8,'1 ,
     *          6HLB)' ,  6H,E5.  ,  6H'(OR  ,  6H/LI',  6H   ,5  ,  6H8,'1 ,
     *          6HLB)' ,  6H,E5.  ,  6H'(OR  ,  6H/LI',  6H   ,5  ,  6H8,'1 ,
     *          6HLB)' ,  6H,E5.  ,  6H'(OR  ,  6H/LI',  6H   ,5  ,  6H8,'1 ,
     *          6HLB)' ,  6H,E5.  ,  6H'(OR  ,  6H/LI',  6H   ,51  ,  6H/1)  /
      DATA ALTR/6H     ,  6H0021 ,
     *     6H'(RO,  6H( 21,  6H( 27,  6H( 51,  6H( 54,  6H( 63,  6H1 78 /
      DATA TIT/6H     ,  6H0,  6H U A,  6H L E,  6H T E,  6H   0,
     *     6H O R,  6H T,  6H I T,  6H O P,  6H S T,  6H S(,  6H ,  6H  /
      DATA RTYPE/6H     ,  'SECTIONPT', 'PRODUCTS',  '   PRODUT', '  ',6H0RDER',
     *' AND QUAT','ION (PRIN',' CTION IO',' ODIC CAL',' LIST CAL',' TRA OUTP',
     *' UTPUT OU',' INFLATION',' IRRATION',' UT ONLY)',' UNIT S)'/
      DATA  UTYPE/' METRIC', ' ENGLISH'/
      DATA  COVMAT/60*1.0/,  COVER/540*0.0/
      DATA  IMPR,SCALEP/540*1.0/,  BOSR,IMBR/2*0/
      DATA  PRP/2*0.0/,  PRI/2*0.0/
      DATA QUALIN/' DON',2*6H    ,' TRS',11*6H    /
      DATA OSUM/' NO '/,  RNOUT/'TRS '/
      DATA IRS/3.0/,  RSIR/0.3/
      DATA JRSP/3.0/,  RSIR/0.0/
      DATA  JRIR/0.0/,  RSIR/0.0/
      DATA  UNIT/' LB ',' KN ',' LB ',' IN '/
      DATA  SPRCU/48*0.0/
      DATA UNITS/'  T ',' CMS ',' FONS ',' CFS '/
      DATA UNIT/' IC) ',' HA ',' IF) ',' ACRE'/
      DATA APSON/540*0.0/,  ASIR/540*0.0/,  APOLP/2*0.0/,  APOLI/2*0.0/
      DATA AIRSUV/540*0.0/,  ASIRV/540*0.0/,  APOLV/2*0.0/,  APOLIV/2*0.0/
      DATA  SNPA,BRA/2*0.0/,  RCSI,ROSIA,BOS/3*0/
      DATA POLTC/540*0.0/,  PLTCAV/540*0.0/
      DATA ACPOLP/2*0.0/,  ACPOLI/2*0.0/
      DATA ACSIR,ACIRBR/10*0.0/
      DATA  ACCP/540*0./,  ACCI/540*0./,  BIRP/540*0./,  BPUR/540*0./
      DATA  SRBP/540*0./,  PR2/540*0./,  LNTS/540/
      DATA  PRPVSU,PRIVSC,PRPRAT,PRIRAT/540*1.,540*1.,60*0.,60*0./
      DATA  ACUP,ACUI,ACUPV,ACUIV/2*0.,2*1200.,2*1200./
      DATA  PUPRA,RETAP,RETBRV,RETIRP/2*1.,2*0.,2*1200.,2*1200./
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      END
      SUBROUTINE LABOR

C
C                                  REP LABOR
C
C
      IMPLICIT  REAL(A,B)

      DIMENSION SVDIST(24),LABOR(24),DYP(97),SHOUT(25,16),STABOR(16),
     1          RNAB(24),RADI(24),TSAVE(24),WINDS(24),DAIN(96),SOWT(6),
     2          SUM2(6)

      COMMON /ALL/ PU,NTRIN,NTCAL,POST,UNIT,TIMPAC,LES,AREA,DESD,DFLAG,
     1          DPOST,SOAR,SNOW,INTP,ROW,ROWS,USED,DEMOB,BIN,PP,TP,
     2          RDPLD,LAST,PREV,PERPE,TAB,IHED,PR,RUI,S,PA,UMP,DOSE,
     3          DPPC(6),TU(6),LLOOSE(6),SI,AE(6),DALIB(6),SI,ROCI,ROS,
     4          NOSTR,DPI,UTAD,UNT(12,2),DNT(12,2),UNT(12,2),BROS,
     5          WCT,DEPW,POSNI,RUSHI,RTSPI(5),SEOS,LAST(5),IHVE(5),
     6          BLANO,NQUAL,STACH(20,20),RECOUT(5),PLOUT,RCALEP(5),
     7          SNOW,BACR,TRACR

      COMMON /LABOR/ DAY,PRTR,IPIN,IS,TWDAL,SUM,JAS,AY,LABCR,LABR,DATE(12),
     1          UZS,IZ,USUM,(A,B),INFIL,INTAN,ROWS,DEC,DOCI,TIM(13),
     2          R2AI,RR2,R2+RL,RP,IPS,G3,RPSRI,CROSS,RRSC,OCPT,EMC,
     3          CROSTT,RAPIN,ROTRA,RETOTT,CCPAC,RCEPT,SNOST,RAIR,RMC,
     4          RCT,IDNS,F,DOS,HC,RPACR,EVAPSR,RELAY,TSNOW,VETALE,
     5          DPRS,CEPTR,ROPTH,TRIM,ULTRAR,FLUIF,CLSR,VIRO3,INFLOR,
     6          TSUBAL,RCOTCR,P/DTOT,DER,ROTION,ROTYCY,YEAR,CONEY(7),
     7          INPTOT,RRAR,RAT,SNCR,POWR(12)

      COMMON /LABOUT/ ROOTOR,RINTOR,RITOR,RUTOR,RACTOR,RCNTOR,PEVCR,
     1          RUNORR,YECOR,AYLRAR,RAIRIR,CUSRER,CORRER,
     2          CHAINP,SORR,RRERORR,PACROT,CRPARR,EPTOR,RRITOR,
     3          UTROT,LUCOT,SOROT,ACTPOT,UTCOT,SROZTO,TYBALO,
     4          TSNOOL,ROSTOT,PINTOT,RITOT,RUTOT,RANTOT,RCNTOR,
     5          PUTOT,SUNORT,PRSNT,RELPAT,RAURET,CORRET,CORRRT,
     6          CRAIRT,ROPT,RRERORT,PACR T,CEVAPT,EPTOT,RRPTOR,
     7          URSRT,LZORT,RURNT,RCEPT,PINST,SROZTT,TWNLRT

      COMMON /STR/ ACPOLT(5),PLTRR(5),POLTSC(5),PLTRRC(5),
     1          ACSRRT,SRRAR,SROTSC,SRORRC,VCTRUR,PRARRU

      LOGICAL LAST, PREV

      INTPORP  TP,UTCAL,DAY, UNIT, SNOW, HRPLAG, H, RPLAG ,LNYR,STRROR,
     1          SRCOUT,YEAR

      REAL  INPIL, INTAN, RR, INPLT, IRC, INT; IRPL
      REAL  TRUE, IEC, IPO; RRETOR, RRETOT
      REAL  TNPTOR, TRPCCY, UNRTOC ,INPR
      REAL  RTRIN, RETORT, WOPLD
      REAL  UZSRAI, LRSORT, ROWART, SUCROT, RRSORT
      REAL  YBOLRT, ORORTA, RTSORT, SRORRT
      REAL LIWS, RPACR, PRLRY, PUOL, RRORLT, RSIRR
      REAL RPLP, TRDY, RCLD, TPACR, RELRAN, RRELRRT

      DATA  PERC, INPLT, SRAR, HRPLAG/0.0,0.0,0.0,6.6,0/
      DATA  PRITY, PREV, SNOW/.FALSE.,.TRUE.,.FALSE./
      DATA  RUSTRR, PRSIR, RPIRT, ALPR, RP/999.0/
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      DATA  EVOUT/0.52,0.0,0.019,3.391,0.057,0.000,0.000,0.194,999.11.0,105.
     C  0.748,0.001,0.000,0.000,0.11,0.546,0/
      DATA  AVO/10.0,.02,.2,.01,.1,.015,1.02,
     C1.01,1.02,1.03,1.04,1.05,1.06,1.07,1.08,1.09,1.1,1.11,1.12,1.13,1.14,
     C1.15,1.16,1.17,1.18,1.19,1.2,1.21,1.22,1.23,1.24,1.25,1.26,1.27,1.28,
     C1.29,1.3,1.31,1.32,1.33,1.34,1.35,1.36,1.37,1.38,1.39,1.4,1.41,1.42,
     C1.43,1.44,1.45,1.46,1.47,1.48,1.49,1.5,1.51,1.52,1.53,1.54,1.55,1.56,
     C1.57,1.58,1.59,1.6/
      DATA  CAPAB/0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9,1.,
     C1.1,1.2,1.3,1.4,1.5,1.6,1.7,1.8,1.9,2.,2.1,2.2,2.3,2.4,2.5,2.6,2.7,2.8,
     C2.9,3.,3.1,3.2,3.3,3.4,3.5,3.6,3.7,3.8,3.9,4.,4.1,4.2,4.3,4.4,4.5,4.6,
     C4.7,4.8,4.9,5.,5.1,5.2,5.3,5.4,5.5,5.6,5.7,5.8,5.9,6.,6.1,6.2,6.3,6.4,
     C6.5,6.6,6.7,6.8,6.9,7.,7.1,7.2,7.3,7.4,7.5,7.6,7.7,7.8,7.9,8.,8.1,8.2,
     C8.3,8.4,8.5,8.6,8.7,8.8,8.9,9.,9.1,9.2,9.3,9.4,9.5,9.6,9.7,9.8,9.9,10./
      DATA  ADE, ADUE/2*0.0/
      DATA  AB1SQ, AINVF, ARDUST/3*0.0/
      DATA  AHU, AHUE, ARDU, ADUST, ADUSTE, ARRAD, ARRCH/7*0.0/
      DATA  BURNN, EVOUT, FCIN, PRIRUN, RRVAPE, RAINR, CLRNR, LIQW1,
     C     CONSR, CRAIN, RECPLT, SNRUN, RIVRUN, LIQR, LIQW, RICE,
     C     SIVOLF, GOR, DOR, WDAL, OBVAR/8*0.0/
      DATA  EVOUT/3R999.0/
      DATA  CLDP/-1.0/
C
C
C                         ZEROING OF VARIABLES
C
      LRR1 = LRR
      URR1 = URR
      NUNI = 0
      DPSI = 0.0
      PACK1 = PACK
      LIQW1 = LIQW
      RRF = 0.
C
      LNRAT=1.E5/LRRR
      DIFW=12.0*TRF*11/(LNRAT*LN RRF)
      DAP= (7/RPAC/RC.)*DIFW
C
C                                                 REDUCE INFILTRATION IF ICE EXISTS
C                                                 AT THE BOTTOM OF THE PACK.
C                                                 ATTEMPT TO CORRECT FOR FROZEN LAND
      IF (UNOR .LT. 1)  GO TO 30
      DAPR = 11.0 -RICE)
      IF (DAPR .LT. 0.1)  DAPR = 0.1
      DAP = DAP*DAPR
C
   20 RATIO= EXP(ERRO*10.0*DIFW*LNRRAT)
      IF (1.-RATIO).LT.(1.0)) RATIO=1.0
      DRRA= DAP*RATIO
      R = TP/DR
C
C
C                                                 IF IS 1 FOR RAIN DAYS AND 99
C                                                 IS ZERO FOR NON-RAIN DAYS
C
      IF (PP .GT. 0)  IRRR=0
C
      DO 1480  III=1,99
C
      LNRAT = LRR/LRRR
      IF (PP .LT. 0)  GO TO 60
      RUNI =RUNI + 1
      IF (RUNI .EQ. 0)  GO TO 30
      GO TO 40
   30 RUNI = 0
C
   40 RRAR = 0.0
      RRCH = 0.0
      RCR = 0.0
      RR = 0.0
```

```
      GWF = 0.0
      RUNT = 0.0
      RUNC = 0.0
      INFLT = 0.0
      PREC = 0.0
C
C     TIMFAC = TIME INTERVAL IN MINUTES
C     L      = LENGTH OF OVERLAND SLOPE
C     RN     = MANNING'S N FOR OVERLAND SLOPE
C     I      = IMPERVIOUS AREA
C     PA     = PERVIOUS AREA
C
C
C
C     PR IS INCOMING RAINFALL
C     PT IS RAIN REACHING SURFACE(.OO'S INCHES)
C     PS IS TOTAL MOISTURE AVAILABLE( IN.)
C     DA IS OVERLAND FLOW STORAGE( IN.)
C     RTOB IS 'D' IN OP. MANUAL
C     DSF IS 'D' IN OP. MANUAL
C     RATIO IS 'C' IN OP. MANUAL
C     EP = DAILY EVAP.( IN.)
C     EPHR = HOURLY EVAP
C     EPIN = INTERVAL EVAP
C     EPRF = FACTOR FOR REDUCING EVAP FOR SNOW AND TEMP
C
C
C
C     DETERMINE IF SNOWMELT IS TO BE DONE
C
   50 HRFLAG=0
      TEST = IMIN/TIMFAC
      IF (NUMI .EQ. 1)  HRFLAG = 1
      IF ((TEST .LE. 1.001).AND.(TEST .GE. 0.999)) HRFLAG = 1
C
C     HRFLAG=1 INDICATES BEGINNING OF THE HOUR
C
      IF (HRFLAG) 770, 770, 60
   60 IPHR = 0
      IF (IHR-24)  70,80,70
   70 IPHR = IHR + 1
      GO TO 90
   80 IHRD = IHRD + 1
   90  EPHR = [illegible]  EPHR=0.0
       IF (EPHR.LE.[illegible])
       EPIN= EPHR
       EPIN1=EPIN
      IF (ISNOW .EQ. 0) GO TO 770
      IF ((PACK .LE. 0.0).AND.(TAIR .GT. [illegible])) GO TO 770
C                          **********************************
C                                    BEGIN SNOWMELT
C                          **********************************
C
       TSNOW1 = TSNOW + 1.
       ANTCMP = 32.
       SEVAP = 0.0
       OFLAG = 0
       DRNH=0.0
       EPRA = 1.0
       IRPHD = 60./(TIMFAC)
       IDT = (IHRD-1)*[illegible]
```

```
C                                   SUB PRECIP FOR THE HOUR
      PX=0.0
      DO 100 II = 1,ENSMB
  100 PRHR = PRHR + RAIP(IPT,II)
C                                   CORRECT TEMP FOR ELEVATION DIFF
C                                   USING LAPSE RATE OF 3.5 DURING RAIN
C                                   PERIODS, AND AN HOURLY VARIATION IN
C                                   LAPSE RATE (LAPSE(I)) FOR DRY PERIODS
C
      LAPS = LAPSE(IHRS)
      IF (PRHR .GT. 0.05)  LAPS = 3.5
      TX = TMPX(IHRS) - LAPS*ELDIF
C
C
C                                   REDUCE EVAP FOR SNOWMELT
C                                   CONDITIONS BASED ON PXTMP AND
C                                   PXTMAX VALUES
C
      IF (PACK-SPACK) 120,120,110
  110 SIN=0.0
      PACKRA = 1.0
      GO TO 130
  120 PACKRA = PACK/SPACK
      SIN=1.0 - PACKRA
  130 PXTX = (1.0-PXTMAX)*10. + X
      IF (TX-PXTMAX)  160,170,170
  140 IF (SPEX .GT. 0.5)  SNEX=0.5
C
C                                   REDUCE EVAP BY SOM IF TX IS BETWEEN
C                                   PXTMIN AND PXTMAX
  150 IF (TX-PXTMIN)  160,170,170
  160 SPEX=0.0
C
C
  170 PRHR = PRHR*PXTEMP
      RSIN=RSIN*SPEX
      ISNO=0
      IF ((TX .GT. TSNOW) .AND. (PRHR .GT. .02)) SNWA = TX
C
C     SET DEWPT TEMP EQUAL TO AIR TEMP WHEN RAINING
C     OR SNOW TO INCREASE SNOWMELT
C
      IF (PRHR .GT. .01) SNWA = TX
      SNTEMP = TSNOW + (TX-TSNOW)*(0.12 + 0.008*TX)
C
C     RAIN/SNOW TEMP: DIVISION - SEE ANDERSON, NWS, VOL. 9, NO. 1,
C     FEB. 1964, P. 37, EQ. 28
C
      IF (SNTEMP .GT. TSNOW) SNTEMP = TSNOW
      IF (TX -SNTEMP) 190, 180, 180
  180 IF  (PACK) 770, 770, 200
  190 SFLAG = 1
      IF ((PACK.LE.0.0).AND.(PRHR.LE.0.01)) GO TO 770
C
C          SKIP SNOWMELT IF BOTH PACK AND PRECIP ARE ZERO
C          FOR THE HOUR
C
  200 IPRO = 1
C
C     SNOWMELT CALCULATIONS ARE DONE IF IT IS SNOWING, OR,
C     IF A SNOWPACK EXISTS
```

```
C
      PX = PXTMP
      IF (PX)  253, 250, 240
C                                        RCLD IS INDEX TO CLOUD COVER
  240 RCLD = 15.
      IF (IFLAG) 260, 260, 220
C                                        SNOW IS FALLING
  220 PX = PXSNOW
      APX = AMIN1(RCP-1.0)*PXTMP
      PXTMP = PXTMP*RCP
      SUMSN = SUMSN + PX
      DNS = DNSN
      IF (PX .GT. 0.0)  DNS = DNS + ((PX/100.)**2)
C
C     SNOW DENSITY WITH TEMP. : APPROX TO FIG. 9, PLATE D-1
C     SNOW HYDROLOGY  SEE ALSO ANDERSON, TR 20, D, 21
C
      PACK = PACK + PX
C
      IF (PACK-IPACK)  260,240,230
  230 IPACK = PACK
      IF (IPACK .GT. PPACK)  IPACK = RPACK
C
  240 DEPTH = DEPTH + (PX/DNS)
      IF (DEPTH .GT. 0.01) SDEN = PACK/DEPTH
      SNOT = SNOT + 1.0*PX
      IF (SNOT .LT. 0.3) SNOT = 0.0
      PX = 0.0
      GO TO 260
  253 RCLD = RCLD - 1.
  260 IF (RCLD .LT. 0.0) RCLD = 0.0
      PACKPA = PACK/IPACK
      IF (PACK .GT. IPACK)  PACKPA = 1.0
C
  270 IF (PACK - 0.005)  280, 310, 300
C
C     IPACK IS AN INDEX TO AREAL COVERAGE OF THE SNOWPACK
C     SET INITIAL STORMS IPACK = .1*PPACK SO THAT COMPLETE
C     AREAL COVERAGE RESULTS.  IF EXISTING PACK > .1 *PPACK THEN
C     IPACK IS SET EQUAL TO RPACK WHICH IS THE WATER EQUIV. FOR
C     COMPLETE AREAL COVERAGE PACKPA IS THE FRACTION AREAL COVERAGE
C     AT ANY TIME.
C
  280 IPACK = 0.1*PPACK
      SICE = 0.0
      SMELT = 0.0
      RMELT = 0.0
      PX = PX + PACK + LIQW
      PACK = 0.0
      LIQW = 0.0
C
C                 CC30 SNOWMELT OUTPUT ARRAY
C
      DO 293 I=1,29
      DO 290 K=1,16
  290 SNOUT(I,K)=0.0
      GO TO 763
  300 PSUMSN = PSUMSN + PX
      IF (DEPTH .GT. 3.7) SDEN = PACK/DEPTH
      IF (SNOT .LT. 800.) SNOT = SNOT + 1.
C                                        SNOT IS INDEX TO ALBEDO
```

```
      RELT = 0.0
      IF (DEPTH .LT. 0.55) DENSTY=DENSTY*(1.0 - 0.5*EXP(-1.55*DEPTH))
C
C     EMPIRICAL RELATIONSHIP FOR SNOW COMPACTION
C
      IF (DEPTH .GT. 0.0) DENS = PACK/DEPTH
      WIN = WINDS(ICARD)
C
C     HOURLY WIND VALUE
C
      LREF = 478 + 10L.1/5
      LREF = IFIX(LREF)
      SVPP = SVP (LREF)
      ITE = IFIX(TE)
      SATVAP = SVPP +(SDR(ITE,5)/5)*(SVP(LREF + 1) - SVPP)
      LREF = (DENS + 100.)/5
      LREF = IFIX(LREF)
      SVPP = SVP (LREF)
      IDENS = IFIX(DENS)
      VAPP = SVPP + (SDR(IID,MM,5)/5)*(SVP(LREF + 1) - SVPP)
C                  CALCULATION OF VAPOR PRESSURE AT AIRTEMP
C                  AND DEWPOINT
      IF (VAPP - 6.108)  320, 320, 310
  310 CHM = 0.500*(VAPP - 6.108)
      GO TO 330
  320 CHM = 0.0
      DUMMY=(VAPP-SATVAP)*PACKPA
      IF (VAPP .LT. SATVAP) EVAP = EVAP*EXP(0.01*DUMMY
      PACK = PACK + EVAP
      EVAPT = EVAPT + EVAP
C
C     CONDENSATION = CONVECTION HELT, EQ. T-298, P.176, SNOW HYDROLOGY
C     CONV = CONVECTION, CCNDS = CONDENSATION
C     EVAP = EVAP FROM SNOW (NEGATIVE VALUE)
C
  330 CNV = 0.0
      IF (TE .GT. 32.) CNV = (TE-32.)*(1.9 + 0.3*(RELHY/10000.))
      CCNC = C/PAC*.00328*WIN
C
C     .00328 = .078629/24. I.E. .00328 IS THE DAILY CONDENSATION
C     (FROM SNOW HYDROLOGY) REDUCED TO HOURLY VALUES.
C
      CONV = CNV*CCNC
      CONDS = CHM*CCNC
C                        CLOUD COVER
C                        CLCF IS FRACTION OPEN SKY - MINIMUM VALUE 0.15
      IF ((IHRS.GE.6).OR.(IHRS.LT.0)) CLCF = (1.0 - 0.085*(RCLD/3.5))
C                        ALBEDO
      IF (MONTH - 9)  340, 340, 360
  340 IF (MONTH - 4)  360, 350, 350
  350 ALBEDO = 1.0 - 0.19(SIN(1HOT/24.))
      IF (ALBEDO .LT. 0.65)  ALBEDO = 0.65
      GO TO 370
  360 ALBEDO = 0.95 - 0.079(SIN(1HOT/24.0))
      IF (ALBEDO.LT.0.5) ALBEDO=0.6
C                        SHORT WAVE RADIATION=SA - POSITIVE INCOMING
  370 SA = RADI(MONE)*(1.0 -ALBEDO)*(1.0-PI)
C                        LONG WAVE RADIATION - LW - POSITIVE INCOMING
      DPOMA = TE - 32.0
      IF (DPOMA)  380, 390, 390
  380 LW = PI 0.26*DPOMA + (1.0 - PI)*(0.2*SIGMA - 0.6)
```

```
      GO TO 490
  190 LW = 597.3+0.562*TA + (1.0 - RI)*(0.17*TA+0.6)
C
C                             LW IS A LINEAR APPROX. TO CURVES IN
C                             FIG. 6, PL 5-3, IN SNOW HYDROLOGY.  0.6
C                             IN STEFAN-BOLTZMAN LOST FROM THE SNOWPACK
C                             IN CAL/CM2/DAY, IN LANGLEYS/DAY.
C
C                             CLOUD COVER CORRECTION
  400 IF (LW .LT. 0.0)  LW = LW*CLOF
C
C                             RAIN MELT
      RAINR = 0.0
C
C                                   RAINMELT IS OPERATIVE IF TA IS
C                                   RAINING AND TEMP IS ABOVE 32 F
C
      IF ((SNPLAG .LT. 1).AND.(TA .GT. 32.1))  RAINR = 0.0125*PR/168.
C                             TOTAL MELT
      RM = (LW + RA)/203.2
C                             203.2 LANGLEYS REQUIRED TO PRODUCE 1 INCH
C                             RUNOFF FROM SNOW AT 32 DEGREES F
      IF (PACK - IPACK ) 510, 510, 530
  510 SR = 1.0*PACKRA
      CONV = CONV*PACKRA
      CONDS = CONDS*.ACKRA
      RAINR = RAINR*PACKRA
      IF (ICOLD - 6)  520, 520, 530
  520 ELMCR = 0.07*(32.0 - TA)
      IF (ELMCR .GT. ELMPLT) ELMCR = ELMCR
  530 RADME = RADME + RM
      CONVP = CONVP + CONDS
      CONVR = CONVR + CONV
      CRAIN = CRAIN + RAINR
      MELT = RM + CONV + CONDS + RAINR
      IF (MELT)  540, 540, 670
  540 MELMR = 0.0
      IF (TA .LT. 32.)  MELMR = 0.006955*(PACK/2.0)*(32.0 - TA)
C
C                                   HALF OF PACK IS USED TO CALCULATE
C                                   MAXIMUM RECEIVED MELT
C
      TP = 32.0 - (MELMLT/(0.006955*PACK))
C
C     TP IS TEMP OF THE SNOWPACK
C     0.006955 IS IN, CAL/IN. SNOW/DEGREE F
C
      IF (TP - TA)  560, 560, 550
  550 DR = 0.00375*(TP - TA)
      MELMLT = MELMLT + DR
      RADME = RADME + DR
  560 IF (MELMLT .GT. PACKRA)  MELMLT = PACKRA
      MELT = 0.0
C
C                             MELTING PROCESS BALANCE
C
  570 PREM = (1.0 - PACKRA)*PR
      PR = PACKRA*PR
C
C     PREM IS FRACTION OF PRECIP FALLING ON BARE GROUND
C
```

```
      IF (RSLT + PX)   610,610,590
C
C     SATISFY NEGRLT FROM PRCP EXCESS(RAIN) AND SNOWRLT
C
  580 IF (RSLT - NEGRIT) 590, 600, 600
  590 NEGRLT = NEGRLT - RSLT
      RSLT = 0.0
      GO TO 610
  600 RSLT = RSLT - NEGRLT
      NEGRLT = 0.0
C
  610 IF (PX - NEGRLT)  620, 630, 630
  620 NEGRLT = NEGRLT - PX
      PACK = PACK + PX
      PX = 0.0
      GO TO 650
  630 PX = PX - NEGRLT
      PACK = PACK + NEGRLT
      NEGRLT = 0.0
C
  640 IF ((PX + RSLT) .EQ. 0.0) GO TO  660
C
C     COMPARE SNOWMELT TO EXISTING SNOWPACK AND WATER CONTENT OF
C     THE PACK
C
      IF (RSLT - PACK)  650, 660, 660
  650 RSLT = PACK + LIQW
      DEPTH = 0.0
      PACK = 0.0
      LIQW = 0.0
      INPT = 0.0
      GO TO 690
  660 PACK = PACK - RSLT
      IF (SDEN .GT. 0.3)  DEPTH = DEPTH - (RSLT/SDEN)
      IF (PACK .GT. 10.**DEPTH)  DEPTH = 1.11*PACK
      IF (PACK - 9.CC1)  670, 680, 680
  670 LIQW = LIQW + PACK
      PACK = 0.0
  680 LIQW = MCC*PACK
      IF (SDEN .GT. 0.6) LIQW = MCC*(3.0 - (3.33*SDEN))*PACK
      IF (LIQW .LT. 0.0) LIQW = 0.0
C
C     COMPARE AVAILABLE MOISTURE WITH AVAILABLE STORAGE IN SNOWPACK
C     -LIQW
C
  690 IF (LIQW + RSLT + PX) - LIQW)  810, 810, 800
  820 PX = RSLT + PX + LIQW - LIQW
      LIQW = LIQW
      GO TO 830
  810 LIQW = LIQW + RSLT + PX
      PX = 0.0
  820 IF (PX - ELWRLT)  850, 840, 810
  830 PX = PX - ELWRLT
      PACK = PACK + ELWRLT
      WICE = WICE + ELWRLT
      ELWRLT = 0.0
      GO TO 850
  840 PACK = PACK + PX
      WICE = WICE + PX
      ELWRLT = ELWRLT - PX
      PX = 0.0
```

```
      GO TO 650
C
C                                   END MELTING PROCESS BALANCE
C
  640 IF (DEPTH .GT. 0.0) BURN = PACK/DEPTH
      IF (BURN .LT. 1.1) BURN = 0.1
C                                   UNDERBURNT
      IF (TEMPR - 1) 100, 670, 700
  670 BURN = BURN
      IF (Z .LT. 0.0)  TP = 5.0
      IF (TP .LT. 32.)  BURN = .BURN - BURN*.039*(32.0 - TP)
      IF (PACK - BURN)  690, 690, 695
  695 PK = PK + BURN
      PACK = PACK - BURN
      DEPTH = DEPTH - (BURN/DENSN)
      GO = GO + BURN
      GO TO 700
  690 PK = PACK + PK + 1.0
      BURN = BURN + PACK
      PACK = 0.0
      DEPTH = 0.0
      LIQW = 0.0
      FROZLT = 0.0
  700 CONTINUE
      PK = PK + PKBT
      GPK = GPK + PK
C
C                                   MONTHLY SUMS
C
      SUMSNW = SUMSNW + SUMSN
      PRSUM  = PRSUM  + PRCPN
      MELWAT = MELWAT + SEE
      PAUMTH = PAUMTH + PAUME
      COUMTH = COUMTS + COUME
      COUMTM = COUMTM + COUME
      CRAITH = CRAITH + CRAIN
      SUMP   = SUMP   + SUM
      SNEUTH = SNEUTH + SNEUN
      SEVAPH = SEVAPH + SEVAPT
C
C                                   YEARLY SUMS
C
      SUMSNY = SUMSNY + SUMSN
      PRSUMY = PRSUMY + PRCPN
      MELWAY = MELWAY + SEE
      PAUMTY = PAUMTY + PAUME
      COUMTY = COUMTY + COUME
      COUMTY = COUMTY + COUME
      CRAITY = CRAITY + CRAIN
      SUMY   = SUMY   + SUM
      SNEUTY = SNEUTH + SNEUN
      SEVAPY = SEVAPY + SEVAPT
C                                   END MONTHLY VALUES
C
      SUMSN = 0.0
      PRCPN = 0.0
      PAUME = 0.0
      COUME = 0.0
      COUMS = 0.0
      CRAIN = 0.0
      SUM = 0.0
      SNEUN = 0.0
      SEVAPT = 0.0
```

```
      SPS = 0.0
C                              SNOWMELT OUTPUT
C
      SNOUT(ISNO,1)  = PACK
      SNOUT(ISNO,2)  = DEPTH
      SNOUT(ISNO,3)  = SURF
      SNOUT(ISNO,4)  = ALSNO
      SNOUT(ISNO,5)  = CLOT
      SNOUT(ISNO,6)  = NEGHLT
      SNOUT(ISNO,7)  = LIQW
      SNOUT(ISNO,8)  = TS
      SNOUT(ISNO,9)  = RA
      SNOUT(ISNO,10) = SM
      SNOUT(ISNO,11) = EV
      SNOUT(ISNO,12) = MELT
      SNOUT(ISNO,13) = CONV
      SNOUT(ISNO,14) = RAINR
      SNOUT(ISNO,15) = CONDS
      SNOUT(ISNO,16) = SICE
      IF (DAILY.EQ.1.OR.NRCAL.GT.1) GO TO 710
C
C  CONVERSION TO METRIC SNOW OUTPUT
C
          SNOUT(ISNO,1)  = PACK*25.4
          SNOUT(ISNO,2)  = DEPTH*25.4
          SNOUT(ISNO,6)  = NEGHLT*25.4
          SNOUT(ISNO,7)  = LIQW*25.4
          SNOUT(ISNO,8)  = 0.556*(TS-32.0)
          DO 720 I=11,16
            SNOUT(ISNO,I)=SNOUT(ISNO,I)*25.4
  720     CONTINUE
C
C
C
  710 IF (NRCAL.GT.1)  GO TO 750
      IF (ISNO .NE. 20)  GO TO 750
      WRITE (6,9020) PSAP(II),RAR(II),DAY
      WRITE(6,9010)
C
      DO 730 I=1,24
      WRITE (6,9011) I,(SNOUT(I,N),N=1,16)
      DO 740 N=1,16
  740 SNOUT(I,N)=0.0
  730 CONTINUE
C
C
 9010 FORMAT(1H1,'HOUR  PACK   DEPTH  SURF   ALSNO  CLOT  NEGHLT  LIQW
     *  TS      RA     SM     EV     MELT     CONV     RAINR   CONDS     SICE')
 9011 FORMAT(' ',I2,3F7.1,F5.1,2F6.1,5(1X,F7.3),1X,F7.2,3(1X,F7.4),
     *5(1X,F7.3),1X,F7.2,1X,F7.3)
 9020 FORMAT (1H1,2X,'SNOW MELT OUTPUT PUP',I3,A5,A6,I3,I2)
C
C                              COMPUTE WATER BALANCE FOR SNOWMELT
C                              PACK AND SURF EVAP
C
C                              PSN IS INCOMING PRECIP
C                              TS  IS MOISTURE TO THE LAND SURFACE
C                              SEVAP IS SNOW EVAP - NEGATIVE
C
  750 SNBAL = PSN+SEVAP-DE-PACK+PACK1-(LIQW1-LIQW)
      IF (ISNOBAL.LT.0.1001).AND.(SNBAL.GT.-0.0001)  SNBAL=0.0
      PSNBAL = PSNBAL + SNBAL
```

```
C
C
      FACDI = HAUR
      ETUWI = LEUR
C                  ****************************************
C                  *                                      *
C                  *                                      *
C                  ****************************************
C                                                  PS IS TOTAL MOISTURE INPUT TO
C                                                  THE LAND SURFACE FROM PRECIP
C                                                  AND SNOWMELT DURING THE HOUR
C
  770 IF (ESNO .GT. 0) PS=PS+ESNO/DD.
C                                                  ENERGY EXCEEDED EVAPORATION
C                                                  DEMAND AT SURFACE DURING THE HOUR
C
C
C
C   * * *    INTERCEPTION  SUBR.     * * *
C
C
C  USURI = MAX. INTERCEPTION STORAGE  FOR THAT DAY
C  SCEP  = ESTIMATED INTER. STORAGE
C  EPS   = AVAILABLE INTER. STORAGE
C  RUI   = INTERVIOUS RUNOFF DURING INTERVAL
C
C
      EPS=SUSRI-SCEP
      IF(EPS.LT.(0.010)) EPS=0.0
      IF (PS-EPS)    780,780,790
  780 ES= PS-EPS
      SCEP = SCEP+EPS
      GO TO 800
  790 SCEP = SCEP+EPS
      PS=0.0
      RU=0.0
      RUI=0.0
C
C ***    OVERLAND INTERVIOUS FLOW ROUTING ***
C
C
C RUSI = VOLUME OF INTERVIOUS OVERLAND FLOW ON SURFACE
C  RUSRI = VOLUME OF OVERLAND INTERVIOUS FLOW TO STREAM
C  RUSRI = VOLUME OF OVERLAND INTERVIOUS U REMAINING ON SURFACE
C
C
  810 IF (AI) 810,810,820
  811 RUI=0.0
      GO TO 833
  820 RUSI=RUISRI
      IF (USRI-0.001) 830,830,840
  830 SUSI=USRI
      PSRI=0.0
      RUSRI=RUI
      GO TO 860
  840 PSI= USRI-(RUSRI)
      PS= (PS)+(1- RUSI
      IF (PSRI-(RUSRI)) 850,850,850
  850 RS= (RUSRI-(PSI)*AI,0)
      GO TO 870
  860 RF= (PS)/2.0
```

```
      GO TO 930
  920 GUSRX= GUSRX-GUSRX
      QUI=QUSRX*A
  930 GO=GUI
C
C
C
C     * * *       INTERCEPTION EVAP       * * *
C
C
C
  940 IF (INDEX .EQ. 0).AND.(IRIN .EQ. 0)  GO TO 950
      GO TO 1000
C
  950 IF  (EVSP)  1000,1000,960
  960 IF (EVSP-EPIN)  970,980,980
  970 EPIN = EPIN - EVSP
      EINT = EINT + EVSP
      EVSP = 0.0
      GO TO 1000
  980 EVSP=EVSP-EPIN
  985 EINT=EINT+EPIN
      EPIN = 0.0
C
C
C     ***  INFILTRATION FUNC.  ***
C  PN FR TOTAL AVAILABLE
C GUSR = SURFACE DETENTION AND INTERFLOW
C GES = SURFACE DETENTION
C GUSX = INTERFLOW  COMPONENT
C  GUI = VOLUME TO ENTER, AFTER EVAP.
C
C
 1000 PN = PI + 1000
      GUSR1 = GUSR
      IF (PN - GES) 1010,1015,1020
 1010 GUSR=(GUSR*1)/(2.1*GES)
      GO TO 1030
 1020 GUSR= PN - 0.5*GES
      IF (PN - GES*2) 1030,1030,1040
 1015 GES = (PN*21)/(2.0*GES)
      GO TO 1050
 1040 GES= PN - 0.5*GES
 1050 GUSX  = GUSR-GES
C
C
C    ***  UPPER ZONE FUNCTION ***
C
C GUP  = % SURFACE DETENTION TO OVERLAND FLOW
C USUR =  UPPER ZONE STORAGE
C UZS  = TOTAL UPPER ZONE STORAGE
C GUSR = ADDITION TO U.Z. STORAGE DURING INTERVAL
C
      IF (USUR.LT.0.01)  USUR=0.0
      USPA= USUR/UUSR
```

```
C
C     * * *      UPPER ZONE EVAP    * * *
C
C
C BEGIN - ACCUM DAILY EVAP POT. FOR L.S. AND C.WATER, I.E
C         POSITION NOT SATISFIED FROM U.Z.
C
C
      IF (IMONI .EQ. 0).AND.(IMIN .EQ. 0)  GO TO 1090
      GO TO 1150
C
1090  IF (EPIN.LE.(0.0))  GO TO 1150
        EFFECT=1.0
        IF(UZSA-0.01)  1150,1100,1100
1100    IF (UZSA-EPIN)  1150,1150,1110
1110    UZSA=UZSA-EPIN
        EVAP= EVAP-EPIN
        SMOIS=SMOIS+PA*EPIN
        GO TO 1150
1120    EFFECT= 0.5*UZSA
        IF (UZFRCT.LT.10.0)  EFFECT=0.01
        IF (UZSA-EPIN*EFFECT)  1140,1140,1130
1130    UZSA=UZSA - (EPIN*EFFECT)
        EVAP= EVAP-(EPIN*EFFECT)
        EPIN=(1.0-EFFECT)*EPIN
        EDIFF=0.0
        SMOIS= SMOIS + (PA*EPIN*EFFECT)
        GO TO 1150
1140    EDIFF= EPIN - UZSA
        EPIN= EPIN + EDIFF
        EDIFF=0.0
        SMOIS= SMOIS + PA*UZSA
        UZSA=0.0
        EVAP=0.0
C
C
C     * * * *    INTERFLOW FUNCTION * * *
C
C     SPAS - INTERFLOW DETENTION STORAGE
C     INTF - INTERFLOW LEAVING STORAGE
C     SMOIS - TOTAL INTERFLOW STORAGE
C     SMIF - TOTAL INTERFLOW LEAVING STORAGE DURING INTERVAL
```

```
C
 1150   [illegible]
        [illegible]
        [illegible]
        [illegible]
        [illegible]
C
C ***    OVERLAND SURFACE FLOW ROUTING ***
C
C
C RSO = VOLUME TO OVERLAND SURFACE DEPRESSION
C ROSW = VOLUME OF OVERLAND FLOW TO STREAM
C ROSR = VOLUME OF OVERLAND F REMAINING ON SURFACE
C
C
      RT= RSO-(ROSW)
      RT= (RSRO)+ RSO
      IF (RSO-(RSRO)) 1170,1175,1160
 1160 RT= RSO*((RT)*99.6)
      GO TO 1180
 1170 RR= (RT)*3.0
 1180 IF (RT-12.0*DT)) 1200,1210,1190
 1190 RR=(RT)*3.0
 1200 IF (RT-(.5*DT)) 1210,1210,1220
 1210 ROSRR= 0.0
      GO TO 1230
 1220 [illegible]
      IF ([illegible]) ROSR=0,[illegible]
 1230 ROSW= RSO-ROSR
        ROSP = ROSRRVA
      ROUTOF = ROSR + ROSW
C
C
C
C          * * *  UPPER ZONE DEPLETION * * *
C
C  DEVPL = DIFFERENCE IN UPPER AND LOWER ZONE RATIOS
C  PERUZ = UPPER ZONE DEPLETION
C  PERU  = TOTAL U.Z. DEPLETION
C  EUPLT = TOTAL EVAPOTRANSPIRATION
C  ROS   = TOTAL OVERLAND FLOW TO THE STREAM
C
        IF (ISNOW .EQ. 1).AND.(IRIN .EQ. 0)  GO TO 1240
        PERUZ = 0.0
        GO TO 1250
C
 1240   DEVPL= ([illegible])-([illegible])
        IF (DEVPL-.1) 1251,1251,1250
 1251    PERUZ=1.[illegible]
C
      IF (ISNOW .GT. 0) PERUZ = PERUZ*PSFS
C
        IF (RATIO - PERUZ) 1261,1260,1270
 1260    PERUZ = 0.0
        GO TO 1280
C
 1270    UZRA=UZRA-PERUZ
         PERU=PERU+PERUZ
         UZRA = UZRA - PERUZ
 1280    EUPLT= PE-UZRA
```

```
                EMPLT=INFLS + INFL
          RNFS = PCAN * RNUP
           UPN= UGR + UNZD
          RGS = RGS + RUNS
          IF (UGR .LE. 0.01E-11) UGR=0.0
C
C END OF BLOCK LOOP
C
            SW=FU + RGS
           IF (ABS(SW) .LT.(0.0001)) GO TO 1290
           GO TO 1300
 1290     LEG = LEG + RNGS
           RGS = 0.0
           RGR = 0.0
 1300     IF (ABS(SW).LT.(0.0001)) GO TO 1310
           GO TO 1320
 1310     LEG = LEG + RNGST/PA
           RNGST = 0.0
            RNGS = 1.0
C
C
C    * * * LOWER ZONE AND GROUNDWATER  * * *
C
C  RGAS  = BASE OUTFLOW
C  RNCH  = RUN OF UNDEVELOPED PERCENTAGE
C PERC  = % OF EVAPOTRANSPIRATION AND U.Z. DEPLETION INTO GRND 1.0
C  PTA   = UNCLOUDFAZED UNDERLOP = PC. PORTION OF INFIL.
C          AND U.Z. DEPLETION CONTRIBUTING GROUNDWATER
C  RINF  = FRACTION OF PTA LOST TO DEEP GROUNDWATER
C
 1320       LZI=1.00+RUNS((LZMAX-LZCN)+1.0)+1.0
            PINF=(1.0/(1.0+EXP(2.5-LZI)))
            IF (LZCN.LT.LZMAX)   PERC=1.0-PERC*PINF*RNRAT
            PTA = DEPLE(LZCPIC)
            PTA = (1.0-PERC)*PINF*2
            IF (INFIL .EQ. 0).AND.(ISCN .EQ. 0)  GO TO 1330
            GO TO 1340
 1330       PI = PI + PERC*PCPU
            PTA = PTA + (1.0-PERC)*PCPU
 1340       LZN= LZN+P3
         PI= PI*(1.0 - RINF)*PA
         GWF=GWMAX*(1.0 + RVGWS)
         RGAS= GWF
         GW=RU+GWF
         RNCH= PIA*RINF*PA
          RUN=RUN + GWF * PI
          GWS=GWS + PI
C
C   * * *       GROUNDWATER EVAP   * * *
C
C
C LOS  = EVAP LOST FROM GROUNDWATER
C
C     NOTE: EVAP FROM UPERATED AND LO IS CALCULATED ONLY DAILY
C
         IF ((HRDFLAG.EQ.1).AND.(IHOP.EQ.24)) GO TO 1350
         GO TO 1410
 1350    IF (GWS .GT. 0.02E-11)  GWS = 0.97*GWS
         LOS= GWS*KVGEL*RSPERM*PA
         RUN=RUN - LOS
         GWS=GWS - LOS
```

```
C
C  * * *        LOWER ZONE EVAP  * * *
C
C  AETB = EVAP LOST FROM L.Z.
C
C
      IF (RETEP.LT.10.0001)  GO TO 1020
      LRAT = LZS/LZSX
      IF (RT-1.0)   1170, 1160, 1160
 1160 RF=0.0
      GO TO 1180
 1170 RF=0.5*(1.0-RT)
 1180 IF (PETB - (RETEP*LRATIO))  1190,1200,1200
 1190 AETB= PETB*(1.0-(RETEP/(2.0-RETEP*LRATIO)))
      GO TO 1210
 1200 AETB= 0.5*(RETEP*LRATIO)
 1210 IF (RT.LT.10.5001)  AETB=AETB*(2.0*RT)
      LZS=LZS - AETB
      SMST= SMST + PARAETB
      ADMST = ADMST + LZA * PARAETB
 1020 BRETB = 0.0
 1030 SMSTI = SMST - SMSTI
C
C
C
C  BBAL = WATER BALANCE IN THE INTERVAL
C  TBBAL = ACCUMULATED WATER BALANCE
C
C
 1040 BBAL = (ELZS-LZSI+UZS-UZSI+(SCRP-SCRPI)*PCA+(SMST-SMSTI)*PC*0.01*
     *       SCRP-SCRPI+SMST-SMSTI+EDU-PDU+EDL-PDL+EAD-PAD)-PRBB*10.0
 1050 IF (ABS(BBAL).LT. 0.00011.AND.(BBAL .GT. -0.0010)) BBAL = 0.0
      TBBAL=TBBAL+BBAL
C
      DDS = FIAREA
      DPST = DPST + DP/
C
C
C                    RESETTING VARIABLES
C
      LZSI=LZS
      UZSI=UZS
      RPCSI=PCSUB
      SCRPI=SCRP
      SMSTI=SMST
      ADSI=ADST
      PERDFI=TPERDF
       ADSAS = ADSAS + SBAS
       ADSRCH = ADSRCH + SRCH
      AET = AETB + PRB
         ADU = ADU + DU
         ADUI = ADUI + DUI
         ADDS = ADDS + DDS
         ADDST = ADDST + DDST
         IF (((UZSI).EQ.0).AND.(ISNIN.EQ.0)) GO TO 1060
         GO TO 1070
 1060    ADPIN = ADPIN + IPERM
```

```
      1970      ARRAY = ARRAY + ONECY
                ARRAY = ARRAY + ONEDY
                ARRAY = ARRAY + ONEHY
                ARRAY = ARRAY + ONEMY
      C
      C     INSC CONTINUE
      C
      C
      C                          CUMULATIVE RECORDS
      C
            DATUR = DATUR + ARU
            DPTUR = DPTUR + ARSTR
            RUTUL = RUTUL + ARU
            ROUTUR = ROUTUR + ARUS
            STTUR = STTUR + ARUI
            RTRTUR = RTRTUR + ARURT
            RETTUR = RETTUR + ARRLY
            RACTUR = RACTUR + ARUAS
            RCUTUR = RCUTUR + ARRCH
      C
                  RCRTUR = RCUTUR + ARURR
                  TURTUT = PCUTCT + ARCUR
                  INPTUR = INPTUR + AIRPY
                  INPTUT = INPTCT + AIRPU
                  RCLTUR = RCLTUR + ARCLTY
                  TURTUT = PCUTCT + ARCUCY
      C
            DRTUT = DRTUT + ARR
            CTUT = CPTUT + ATSTR
            RUTUT = RUTUT + ARU
            ROUTUT = ROUTUT + ARUS
            TTTUT = TTTUT + ARUI
            RTRTUT = RTRTUT + ARURT
            RETTUT = RETTUT + ARRLY
            RACTUT = RACTUT + ARUAS
            RCUTUT = RCUTUT + ARRCH
      C
      C           LOGICAL VARIABLES LAST AND PREV ARE USED TO DETERMINE
      C           OTHERWISE END OF EACH STORM, WHICH OCCURS IF NO
      C           IS LESS THAN HENRY IN ONE TIME INTERVAL, AND OCCURS IN
      C           THE FOLLOWING ONE (LAST=.FALSE. , LAST=.TRUE.) , OTHER ERRS
      C           IF THE OPPOSITE OCCURS (PREV=.TRUE. , LAST=.FALSE.)
      C
            RUTUR=RU
            TU = (DUMAREA*0.5*0.1/(TIMPAC*12.)
            IF (ITU.GE.HENRY).AND.(TT.LT.2)  GO TO 1990
            LAST=.FALSE.
            GO TO 1970
      1980  LAST=.TRUE.
            IF (PREV) GO TO 1950
      C
      C           COUNT NUMBER OF STORMS AND PRINT SIZE OF STORM OCCURRING
      C
            NUM=NUM+1
            IF (NUM.EQ.1) WRITE(6,1040)
            WRITE (6,1050) NUM,ARAR(IS),ARAR(IT),TIAR
            STORUR(I)=ARAR(IS)
            STORUR(2)=DAT
            STORUR(3)=TUR
            STORUT(I)=IPIR
      C
```


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```
C          INITIALIZATION OF VARIABLES FOR STORM SUMMARY
      NRSL=0
      TOTSUM=0.
      PERVOL=0.
      ACSUMP=0.
      SRUNM=0.
      SRETNC=0.
      SRUNMC 0.
      DO 1495 I=1,5
      AVPOLT(I)=0.
      PLSRA(I)=0.
      POLTNC(I)=0.
      PLSRAC(I)=0.
 1495 LNTS(I)=0
C
C          PRINT INITIAL CONDITION FOR A NEW STORM
C
      IF (MTCAL.EQ.1) GO TO 1536
      WRITE (6,9361) NHP,ARUN
C
C          CALCULATE AND PRINT AREA ACCUMULATION FOR (1) EACH
C          LAND TYPE USE (WEIGHTED BY % OF PERVIOUS AND IMPERVIOUS
C          AREAS), (2) THE ENTIRE WATERSHED AND THE TOTAL PERVIOUS
C          AND IMPERVIOUS AREAS (WEIGHTED BY % OF VARIOUS LAND TYPE USE)
C
       TPI=0.0
       TPR2=0.0
       TPR1=0.0
       TIMP=0.0
      DO 1510 I=1,NLAND
      TPR=APER(I)*(1.-TIMPR(I))*TA(I)/SUMPR(I)
      WUFUN1=(AU(I)/AU(A)*(1.-IMPR(I))
      WUFUN2=(AR(I)/AREA)*IMPR(I)
      TPI=TPI+WUFUN1
      TPR2=TPR2+TR(I)*WUFUN2
      TPR1=TPR1+WUFUN1
      TIMP=TIMP+WUFUN2
      IF (UNIT.GT.3) GO TO 1500
      WRITE (6,9362) (LNDUSE(IN,I),IN=1,3),TPR,SMAP(I),TA(I)
      GO TO 1510
 1500 TPR=APER(I)*2.54
      TIMP=TA(I)*2.54
      SMP=SMP*2.54
      WRITE (6,9370) (LNDUSE(IN,I),IN=1,3),TPR,TPR1,TPR2
      IF (LNTS(I).EQ.1) WRITE (6,9380)
 1510 CONTINUE
      IF (ULAND.GT.1) GO TO 1530
      IF (TPR1.GT.0.) TPR1=TPR1/TPR1
      IF (TPR1.LE.0.) TPR1=0.0
      IF (TPR2.GT.0.) TPR2=TPR2/TPR2
      IF (TPR2.LE.0.) TPR2=0.0
      TPR=PERV*(1-A)+IMPA
      IF (UNIT.EQ.1) GO TO 1520
      TPR=TPR*2.54
      TPR1=TPR1*2.54
      TPR2=TPR2*2.54
 1520 WRITE (6,9390) TPR,TPR1,TPR2
 1530 CONTINUE
      WRITE (6,9391)
      IF (NVCAL.GT.1) GO TO 1560
      WRITE (6,9110) NPL
```

```
C
C                 PRINT DATE, TIME, AND FLOW
C
C
      WRITE (6,9130) MONTH(IB),DAY,YEAR,IHIN
      WRITE(6,9131)
      FLOUT=0.0
      IF (UNEXT.GT.0) FLOUT=QRETRN
      WRITE (6,9132) FLOUT
      IF (NSTEP.NE.0) GO TO 1560
      DAYOUT(1)=DAYNAM(IDA)
      MOUT(1)=MONTH
      DAYOUT(2)=DAY
      HROUT(2)=IHIN
      HROUT(3)=IMIN
1560  IF (PUMP.GT.0.0.AND.NSTEP.EQ.0) PEAKPU=PU
      TOTRUN=TOTRUN+RUTNCH
1570  APR = 0.0
      AMAY = 0.0
      AJUN = 0.0
      AJUL = 0.0
      AAUG = 0.0
      ASEPT = 0.0
      AOCTB = 0.0
      ANOVB = 0.0
      ADECB = 0.0
         AJANB = 0.0
         AFEB = 0.0
         AMARB = 0.0
      IF (CLAST.GE.,NOT.PRNT) GO TO 1650
C
C                    STORM SUMMARY
C
C
      IF (NSTEP.LE.1) GO TO 1590
      TOTFLO=TOTFLO+0.5
      PEAKPU=PEAKPU+0.5001
      ACSUMP=ACSUMP+0.9072
      SREQ=0.0001*1.055
      DO 1580 I=1,NOWAT
      ACPOLT(I)=ACPOLT(I)*0.859
1580  DLTRS(I)=DLTRS(I)*0.859
1590  WRITE (6,9152)
      IF (NSTEP.EQ.0) WRITE (6,9150)
      WRITE (6,9160) NOS
      WRITE (6,9161) NOS1,(STORNO(I),I=1,9),MOAN(IB),DAY,IHR,
     1IMIN
C
C                    IRIR,PEAK,TOTRUN,UPL,PEAKPU
C
      IF (NSTEP.EQ.1) GO TO 1610
      WRITE (6,9162) (ACPOLT(I),I=1,9),(ACPOLT(I),I=11,NOWAT)
      WRITE (6,9163) (DLTRS(I),I=1,9),(DLTRS(I),I=11,NOWAT)
      WRITE (6,9164) SREQ,TOTFLO,(DLTRS(11),I=1,NOWAT)
      SREQ=SREQ*5280/3600
      DO 1630 I=1,9
1630  POLTOT(I)=POLTOT(I)/NOS1
      DO 1640 I=1,NOWAT
      SUM(I)=POLTOT(I)/SCALEP(I)
1640  SUM2(I)=DLTRS(I)/SCALED(I)
```

```
      WRITE (1,8470) (STORE(I),I=1,NVALS)
      WRITE (5,8470) (RSUREC(I),I=1,NVALS)
 1610 WRITE (6,8480)
C
C          ACCUMULATION FOR OVERALL STORM SUMMARY
C
      IF (NTEAM.NE.1) GO TO 1630
      STACH(NOST,NOS,1)=TOTRUN
      STACH(NOST,NOS,2)=BRAKRO
      GO TO 1640
 1630 IF (NOST.NOS.GT.1) GO TO 1640
      STACH(NOST,NOS,1)=AUSLOT
      STACH(NOST,NOS,2)=BRUNK
      STACH(NOST,NOS,3)=ENTRC
      STACH(NOST,NOS,4)=BRUNKC
      DO 1635 I=1,NEQUAL
      K1=K+I
      STACH(NOST,NOS,K1+1)=AUPULT(I)
      STACH(NOST,NOS,K1+2)=TLTRE(I)
      STACH(NOST,NOS,K1+3)=POLTSC(I)
      STACH(NOST,NOS,K1+4)=ULTRSC(I)
 1635 CONTINUE
      WRITE (6,8490)
 1640 CONTINUE
      DRIV=LAST
C
C                    FORMAT STATEMENTS
C
 8010 FORMAT ('0')
 8060 FORMAT (1X,'***',70X,'** LIMIT REACHED **')
 8480 FORMAT ('1')
 8350 FORMAT (1H1,/,13X,9(1),/,1(1),55X,'OUTPUT FOR STORM NO.',I3,
     1    /,1(1),49,A8,1X,19(
 8460 FORMAT (//,12,'ACCUMULATION OF DEPOSITS ON GROUND AT THE ',
     1    'BEGINNING OF STORM',A8,'.',A8,
     2    /,33,'LAND USE',8X,'WEIGHTED MEAN',9X,'PREVIOUS',8X,
     3    '(APPLIED)',/)
 8370 FORMAT (11,3A8,9X,F7.3,2(12X,F7.3))
 8380 FORMAT (36,'WEIGHTED MEAN',8X,F7.3,2(12X,F7.3))
 8390 FORMAT (/)
 8100 FORMAT (10X,'DATE    TIME    FLOW    TEMP  IO(PPM)   SBOD8(PPM
     1    'SBOD5,SAND))
 8110 FORMAT (' DATE    TIME    FLOW (',A6,')')
 8120 FORMAT (1X,'MEAN',F8.3)
 8130 FORMAT (13,A8,/,10,'0',':',I2)
 8140 FORMAT (/,' SUMMARY FOR STORM #',I3)
 8150 FORMAT (29('-'))
 8160 FORMAT (/,' NUMBER OF TIME INTERVALS',I5,/,
     1    ' STORM BEGINS',I5,A8,I5,I2,':',I2,/,
     2    ' STORM ENDS',I5,A8,I5,I2,':',I2,/,
     3    ' TOTAL FLOW (',A6,') ',F10.3,/,
     4    ' PEAK FLOW (',A6,') ',F10.3)
 8170 FORMAT (1X,' SUSPENDED ',A6,' LOAD',F10.3,' LBS')
 8180 FORMAT (' TOTAL RAINFALL (',A6,') ',F10.3,' IN',F10.3,' CM')
 8190 FORMAT (' MAX RAINFALL ',A6,' (',I2,':',I2,') ',F10.3,' IN',F10.3,' CM')
 8200 FORMAT (' PEAK CONCENTRATION (MG/L) ',F10.3,' IN',F10.3,' CM')
 8210 FORMAT (' MAX CONCENTRATION (MG/L) ',F10.3,' IN',F10.3,' CM')
C
      RETURN
      END
      SUBROUTINE QUAL
```

```
C
C
      DIMENSION POLPI(5),POLPI(5),PIPI(5),POLTPI(5),PUPI(5),
     1          TPI(5),PIPI(5),CHAN(5),RRR(5),WSWP(120)
C
      COMMON /ALL/ MU,NYRIN,NYEAR,NDAY,NHRIP,PIPI,LIN,AREA,PEED,OFLAG,
     1             DRAD),DROP,CROP,RUSP,DOL,DUCT,UISD,DISCD,DIA,PI,TP,
     2             NOVID,LAND,PROV,PIMPS,TUP,TUPD,PD,NU(A,PE,U,DP,DOSE,
     3             NOBSE(5),TU(5),CNOUSU(5,5),AD(12,5),WOSI(12,5),WOSI,DOA,
     4             NOOSA,OPI,OTBD,DEVI(2,5),DUT(12,5),IP,WOOD,
     5             WUP,DPRM,DOOOI,PRSOI,PPOIS(5),XROO,LAPD(5),IRV(5),
     6             DLAOD,NUOAI,CSSCH(365,20),DILOUT(5),FLOUT,DCALEP(5),
     7             DROO,PACM,IPACR
C
      COMMON /ULO/ WORKAP(5),RRRR,ARRR,RRRR,JDFP,PRMPUP,CUTPAT(5,12),
     1             PPIP,JDIR,IOO,ANP(5),AOI(5),AUUP(5),AWC(1),OPRD(5),
     2             DRPIP,SI,PMIP,SI,USUOR,SDOOI,DSUPA,DLDPI,DLDVOI,
     3             ACUMOLP(5),ACURRR(5),ROOLPI(5),ALD(365),COVRD(5),
     4             APOLPI(5,5),ACPI(5),ABIR(5),POLTA(5),POLPI(5),
     5             TIMPA,DOA,POLTCAI(5),CHRUT(5),AUINF(5),APOLPI(5,5),
     6             APOLPI(5,5),POLPC(5),PLTUAT(5),ACPOLP(5,5),OIMP(5)
C
      COMMON /OPS/ ACPOLP(5),CLTPE(5),POLTPC(5),PLTPPU(5),
     1             ACUSOP,SDOPE,SDOPAC,SDOPAC,TOTPOR,PPAPAU
C
      DIMENSION LIN2(5),LIN1(5)
      DUAL  JDAYA,PPOP,JDAYO,DATE,PPOP,JDIR
      EXTPOUP NYEAR,YP,UNIT,LNTS ,PPOOUP,DILAS
C
      DEALPP WORKAPP
      DO 10 I=1,5
      LIN2(I)=.0
   10 LIN1(I)=.0
C
      IF (YP.GT.2) GO TO 350
C
C          CONVERT ROOO = VOLUME OF OVERLAND FLOW REACHING STREAM *
C                         IN INCHES PER WHOLE WATERSHED TO INCHES
C                         PER PREVIOUS AREAS ONLY
C
      IF ((1.-A).GT.0.000001) GO TO 20
      ROOO=0.5
      GO TO 30
   20 ROOO=POOO/(1.-A)
   30 CONTINUE
      DO 90 I=1,NIARO
C
C                   IF CAIN CN OROO, INCREASE COVER BY % OF OROO COVER
C
      IF (OROO.EQ.0.OR.IPACR/IPACR1.LT.COVRD(I)) GO TO 35
      CO=(COVRD(I)-1.)*IPACR/IPACR1
      IF (CO.LT.COVRD(I)) GO TO 35
      IF (CO.LE.1.) COVRD(I)=CO
   35 CONTINUE
C
C                         WASHOFF FROM PREVIOUS AREAS
C
      IF (DFLAG.EQ.1) GO TO 40
C
C                   IF CROPS, DRAINS OVER FIXED CONSERVATION
C
```

```
C
C                    MONTHLY ACCUMULATION OF RUNOFF FROM PERVIOUS AREAS
C
      DO 80 J=1,NQUAL
      PULPS(J)=PULPS(J)+(PRMV(J)*12/100.)*3600.
      AVPOLS(J)=AVPOLS(J)+PULPS(J)
   80 APOLPS(J)=AVPOLS(J)*PULPS(J)
      AQUPRS=AQUPRS+QPERV
      APERV=APERV+PERV
  90  CONTINUE
C
C                              RUNOFF FROM IMPERVIOUS AREAS
C
      DO 190 I=1,NLAND
      IF (IMPERV(IPRUN).GT.0.) GO TO 110
      QIMP=0.0
      DO 100 J=1,NQUAL
  100 POLIM(J)=0.0
      GO TO 190
  110 TQUIM=QIMP*(1.-IMPERV(IPRUN))*DELTM
      IF(TQUIM) 120,130,130
  120 TQUIM=0.0
      QIMP=0.0
  130 DO 140 J=1,NQUAL
      POLIM(J)=POLIM(J)+(PRMV(J)*12/100.)*3600.
      APOLIM(J)=APOLIM(J)+POLIM(J)
  140 AVPOLI(J)=APOLIM(J)*POLIM(J)
      AQUIMP=AQUIMP+QIMP
      AIMP=AIMP+IMPERV(IPRUN)
  190 CONTINUE
C
C                              GROUNDWATER TEMPERATURE AND DISSOLVED OXYGEN
C                                                    (ASCE,1969;IBM,
C
      TGRND=(GRNDTP(IPRUN)*9/5)+32.1*5/9
      IF (GRNDTP.GT.0.01) TGRND=0.0
      DO 15,ESZ=0,0 TGRND=1.,DISSOX(IPRUN)=.0000277*(TGRND+5)
C
C                              RUNOFF SUMMARY FOR A GIVEN TIME INTERVAL
C
      DO 193 J=1,NQUAL
      POLT(J)=0.000
```

```
      DO 150 I=1,NLAND
      POLTEMP(I,J)=POLT(I,J)+POLTS(I,J)
      POLT(I,J)=POLTEMP(I,J)+POLTS(I,J)
  150 CONTINUE
      AVPOLT(J)=AVPOLT(J)+POLT(J)/2000.
      IF (MOD(TIME,OUT).EQ.0.) PLOT(J)=AVPOLT(J)
      POLTQ(J)=POLT(J)*SQRT(QSURF(J)/(1000*RHOAIR(J)))
      POLTS(J)=POLTS(J)+POLTQ(J)
      IF (POLTQ(J).GT.PLOMAX(J)) PLOMAX(J)=POLTQ(J)
      POLTQA(J)=POLTQ(J)*ACOV(J)
  160 CONTINUE
      SEDTOT=0.0D0
      DO 170 I=1,NLAND
      SEDT=SEDT+SEDOUT(I)*AIR(I)
  170 CONTINUE
      AVSEDT=AVSEDT+SEDT
      SEDT=SEDT*1000.
      IF (SEDT.GT.SPIKE) SEDMAX=SEDT
      SEDTOT=SEDTOT+SEDT*(TOUTIMPAC*60.0D0,0.0D0,1D)
      SEDTOU=SEDTOU+SEDT
      IF (MOD(TIME,OUT).EQ.0.0D0) SEDAVG=SEDTOU
C
C                         PRINTING OF OUTPUT FOR  EK TIME INTERVAL
C
      TEMP=TEMPS(1)*SURFACE
      IF (TEMP.LT.32.0) TEMP=32.00
      DOA=DOA*DQ
      TEMPA=TEMPA+TEMP
      SEDTA=SEDTA+SEDT
      NOTES=NOTES+1
      IF (DQ.LT.0.0001) GO TO 270
      IF (DQ*12.EQ.-1) GO TO 190
      TEMP=ZERO
      SEDT=SEDTOT*.666
      DO 180 J=1,NQUAL
  121 POLT(J)=POLT(J)*0.666
  181 CONTINUE
      WRITE(IP,9001) TEMP,DQ,SUSP,SEDTOU,(POLT(J),POLTQ(J),J=1,NQUAL)
      IF (MOD(TIME,12.0).GT.0) GO TO 2C7
      WRITE(IP,9111) (SEDCUT(I),I=1,5),PLOUT,
     *               TAPP,DQ,SUSP,SEDTOU,(POLT(J),POLTQ(J),J=1,NQUAL)
C
C          PRINT OF ADDITIONAL OUTPUT FOR CALIBRATION RUN
C
  207 IF (IDAY.LE.6.OR.(IDAY.GE.20.AND.IDAY.LE.24)) GO TO 270
      OUT=(OUTPAPER*0.0508)*(1/(TOUTIMPAC*720.))
      TEM=0.0
      IF (OUT.LT.1) GO TO 210
      TEM=(INT(OUT)-0.0001)
      OUT=OUT-0.0001
      PR=PR+25.0
  210 WRITE(10,9010) OUT,DPL
      WRITE(6,9010) OUT,DPL
      WRITE (16,9011) PR,DEPTH
      DO 240 I=1,NLAND
      ERAT(I)=ERAT(I)*1000.
      ELAST(I)=ELAST(I)*1000.
      TEMP(I)=TEMP(I)*(9/5)+32
      IF (TEMP.LE.0.0C1) GO TO 230
      IF (IDAY.LT.11) GO TO 240
      TEMP=TEMP+.454
```


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```
                  SIG(I)=SIG(I)*0.454
                  ERR(I)=ERR(I)*0.454
                  DO 255 J=1,NQUAL
                  POLTLU(I,J)=POLTLU(I,J)*0.454
                  POLP(I,J)=POLP(I,J)*0.454
              220 POLT(I,J)=POLT(I,J)*0.454
              255 WRITE(6,4070) (HOUSE(KK,I),KK=1,3),TSD,(POLTLU(I,J),J=1,NQUAL)
                  IF (LINE(I).EQ.0)
                 *                 WRITE(6,4050) COVER(I),ISUR(I),(POLP(I,J),J=1,NQUAL)
                  IF (LINE(I).EQ.1)
                 *                 WRITE(6,4060) COVER(I),ISUR(I),(POLP(I,J),J=1,NQUAL)
                  IF (LINE(I).EQ.0) WRITE(6,4070) SIG(I),(POLT(I,J),J=1,NQUAL)
                  IF (LINE(I).EQ.1) WRITE(6,4080) SIG(I),(POLT(I,J),J=1,NQUAL)
              265 CONTINUE
                  WRITE (6,4090)
                  GO TO 270
C
C         ACCUMULATION OF DEPOSITS DURING THE NO RAIN DAYS
C
              250 DO 260 I=1,NLAND
                  TOT(I)=TOT(I)+(1.0-DIRP(I))*ACCU(I)
                  DEP(I)=DEP(I)+DIRP(I)*ACCU(I)
                  IF (DIRP(I).LE.0.0) GO TO 260
                  PRA=ACCU(I)/DIRP(I)
                  IF (IFIX(PRA).GT.TSD) GO TO 260
                  TOT(I)=TSD
                  LAT(I)=+1
              260 CONTINUE
              270 CONTINUE
C
             4050 FORMAT (1X,I2X,F5.2,2F5.3,F7.3,2F8.1,5(10.2,F8.1))
             4060 FORMAT (1X,I2,'TOTAL FLOW',F8.3,' ',5A4)
             4070 FORMAT (1X,'PRECIPITATION',F7.3,' ',5A4)
             4080 FORMAT (1X,'DEPOSITION',F7.3,' ',5A4)
             4090 FORMAT (1X,'SOURCE',15X,'TOTAL',5(10X,'POLL',I2))
             4060 FORMAT (1X,'RECEPTOR',I5,2X,'TOTAL',5(10X,'POLL',I2))
             4070 FORMAT (1X,'SOURCE',I5,2X,F10.3,5(F10.3,5X))
             4080 FORMAT (1X,'DEPOSITION',F7.3,5(F10.3,5X))
             4090 FORMAT (1X)
             4100 FORMAT (5A4,4X,I5,I2,I3,I2,I2,1X,I1,I2,F9.3,F5.1,F5.2,F5.2,
                 *        F4.3,5(F10.3,F8.3))
C
                  RETURN
                  END
C*
//LKED.SYSLMOD DD DSNAME=MYL.S2.S20.TOXT.T7500.OBJ(&&111570),
//             DISP=(NEW,PASS),SPACE=(TRK,(15,1,1),RLSE),UNIT=DISK,
//             VOL=SER=PUB005
//LKED.SYSIN DD *
    NAME  RPS
/*
```